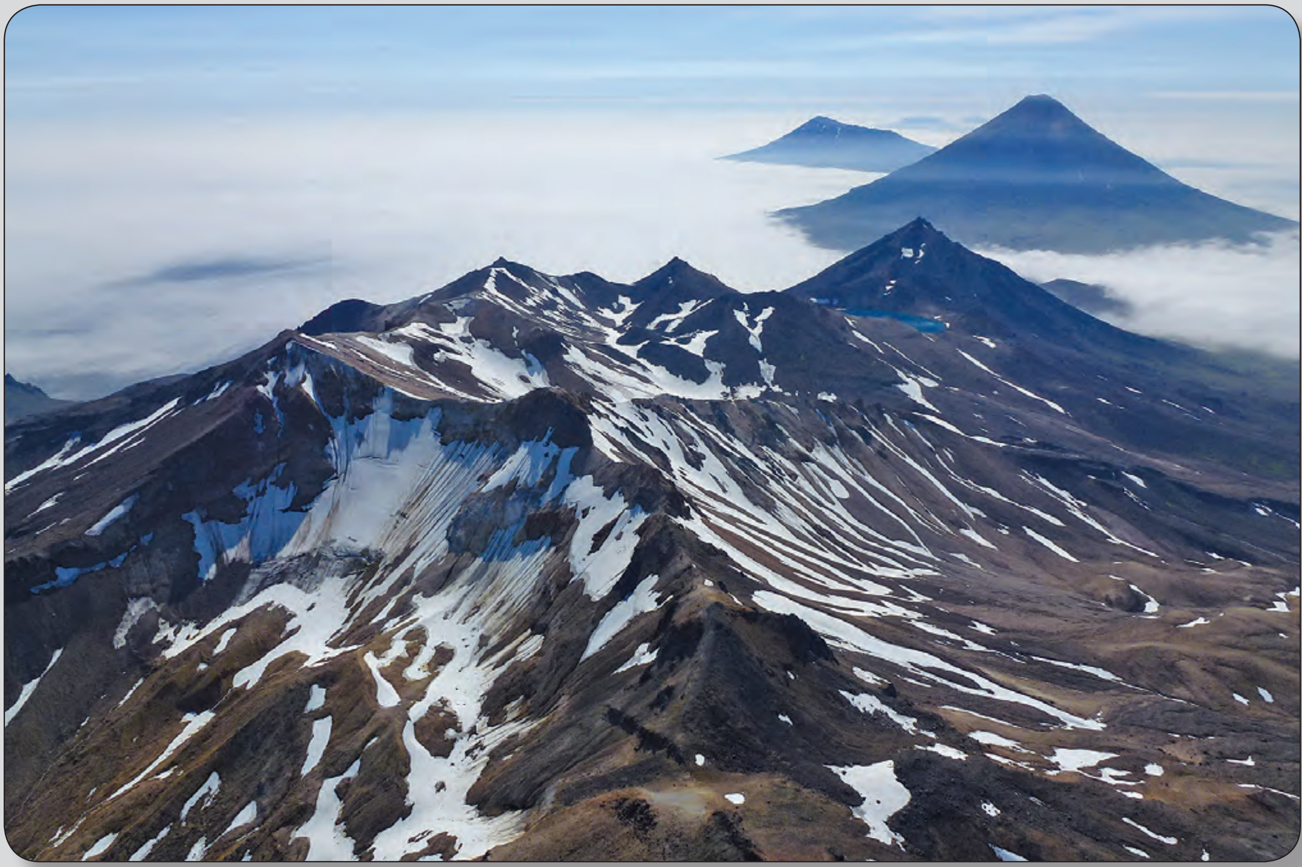
The Alaska Volcano Observatory is a cooperative program of the U.S. Geological Survey, University of Alaska Fairbanks Geophysical Institute, and the Alaska Division of Geological & Geophysical Surveys. The Alaska Volcano Observatory is funded by the U.S. Geological Survey Volcano Hazards Program and the State of Alaska.

2014 Volcanic Activity in Alaska: Summary of Events and Response of the Alaska Volcano Observatory



Scientific Investigations Report 2017–5077

U.S. Department of the Interior
U.S. Geological Survey

Cover: Aerial view of Tana, Cleveland, and Herbert volcanoes, in order from foreground to background. Photograph by John Lyons, USGS/AVO, July 29, 2014.

2014 Volcanic Activity in Alaska: Summary of Events and Response of the Alaska Volcano Observatory

By Cheryl E. Cameron, James P. Dixon, Christina A. Neal , Christopher F. Waythomas, Janet R. Schaefer , and Robert G. McGimsey

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Scientific-Investigations Report 2017–5077

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
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U.S. Geological Survey, Reston, Virginia: 2017

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
cubic mile (mi^3)	4.168	cubic kilometer (km^3)
foot (ft)	0.000305	kilometer (km)
foot (ft)	0.3048	meter (m)
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
tons per day (ton/d)	0.9072	metric tons per day

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as

$$°C = (°F – 32) / 1.8.$$

International System of Units to U.S. customary units

Multiply	By	To obtain
cubic kilometer (km^3)	0.2399	cubic mile (mi^3)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	3,281	foot (ft)
meter (m)	3.281	foot (ft)
centimeter (cm)	0.3937	inches (in.)
millimeter (mm)	0.03937	inch (in)
millimeter per year (mm/yr)	0.03937	inch per year (in/yr)
Liters per minute (L/min)	0.2642	gallons per minute (gpm)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as

$$°F = (1.8 \times °C) + 32.$$

Datum

Altitude and elevation as used in this report refer to distance above sea level, unless otherwise noted.

Locations in latitude and longitude are presented in degrees and minutes rounded to the nearest minute referenced to the World Geodetic System of 1984 (WGS 84) datum.

2014 Volcanic Activity in Alaska: Summary of Events and Response of the Alaska Volcano Observatory

By Cheryl E. Cameron[1], James P. Dixon[2], Christina A. Neal[3], Christopher F. Waythomas[4], Janet R. Schaefer[1], and Robert G. McGimsey[4]

Abstract

The Alaska Volcano Observatory (AVO) responded to eruptions, possible eruptions, volcanic unrest or suspected unrest, and seismic events at 18 volcanic centers in Alaska during 2014. The most notable volcanic activity consisted of intermittent ash eruptions from long-active Cleveland and Shishaldin Volcanoes in the Aleutian Islands, and two eruptive episodes at Pavlof Volcano on the Alaska Peninsula. Semisopochnoi and Akutan volcanoes had seismic swarms, both likely the result of magmatic intrusion. The AVO also installed seismometers and infrasound instruments at Mount Cleveland during 2014.

Introduction

The Alaska Volcano Observatory (AVO) monitors, studies, and warns of volcanic unrest at Alaska volcanoes. This report summarizes notable volcanic activity in Alaska during 2014 (fig. 1**;** tables 1 and 2) and briefly describes AVO's response. We include information on all volcanoes at elevated alert levels and those that prompted increased attention by AVO staff, even if no formal public notification was made. We also include observations, images, and data that are difficult to publish elsewhere.

As of December 31, 2014, 32 of the more than 50 historically active volcanoes in Alaska are instrumented with a network of seismometers sufficiently reliable in their operation to detect and track earthquake activity (table 3). Not included in this list is the Cleveland geophysical network that requires a seismic station in Nikolski, 75 km (47 mi) from Mount Cleveland, to locate earthquakes. Additionally, Mount Wrangell, Fourpeaked Mountain, and Aniakchak Caldera are not considered to be seismically monitored because of network-wide outages in 2014.

AVO's volcano monitoring program (tables 4 and 5) includes daily analysis of satellite imagery, Web camera images, and seismicity; occasional overflights and airborne-gas measurements; compilation of pilot reports (PIREPS); and observations by local residents and mariners. AVO also receives real-time deformation data from permanent Global Positioning System (GPS) stations at eight Alaska volcanoes (Okmok, Makushin, Akutan, Redoubt, Spurr, Augustine, Shishaldin and Westdahl). Moreover, periodic analysis of Interferometric Synthetic Aperture Radar (InSAR) imagery is used to detect deformation at volcanoes in Alaska (for example, Lu, 2007). Finally, AVO is becoming increasingly reliant on infrasound to detect explosions throughout the Aleutian arc (for example, Fee and others, 2010).

As part of AVO's longstanding close cooperation with Russian volcano monitoring and reporting groups in the Russian Far East (Neal and others, 2009), earlier versions in this report series included summaries of activity in Kamchatka and the Kurile Islands (table 6). Beginning with the 2011 report (McGimsey and others, 2014), AVO no longer included this information. Interested readers instead may visit the Web sites of the Kamchatka and Sakhalin Volcanic Eruption Response Teams (KVERT and SVERT, respectively; http://www.kscnet.ru/ivs/kvert/index_eng.php and http://www.imgg.ru/?id_d=659), as well as the Smithsonian Institution Global Volcanism Program (GVP) (http://volcano.si.edu/), for information.

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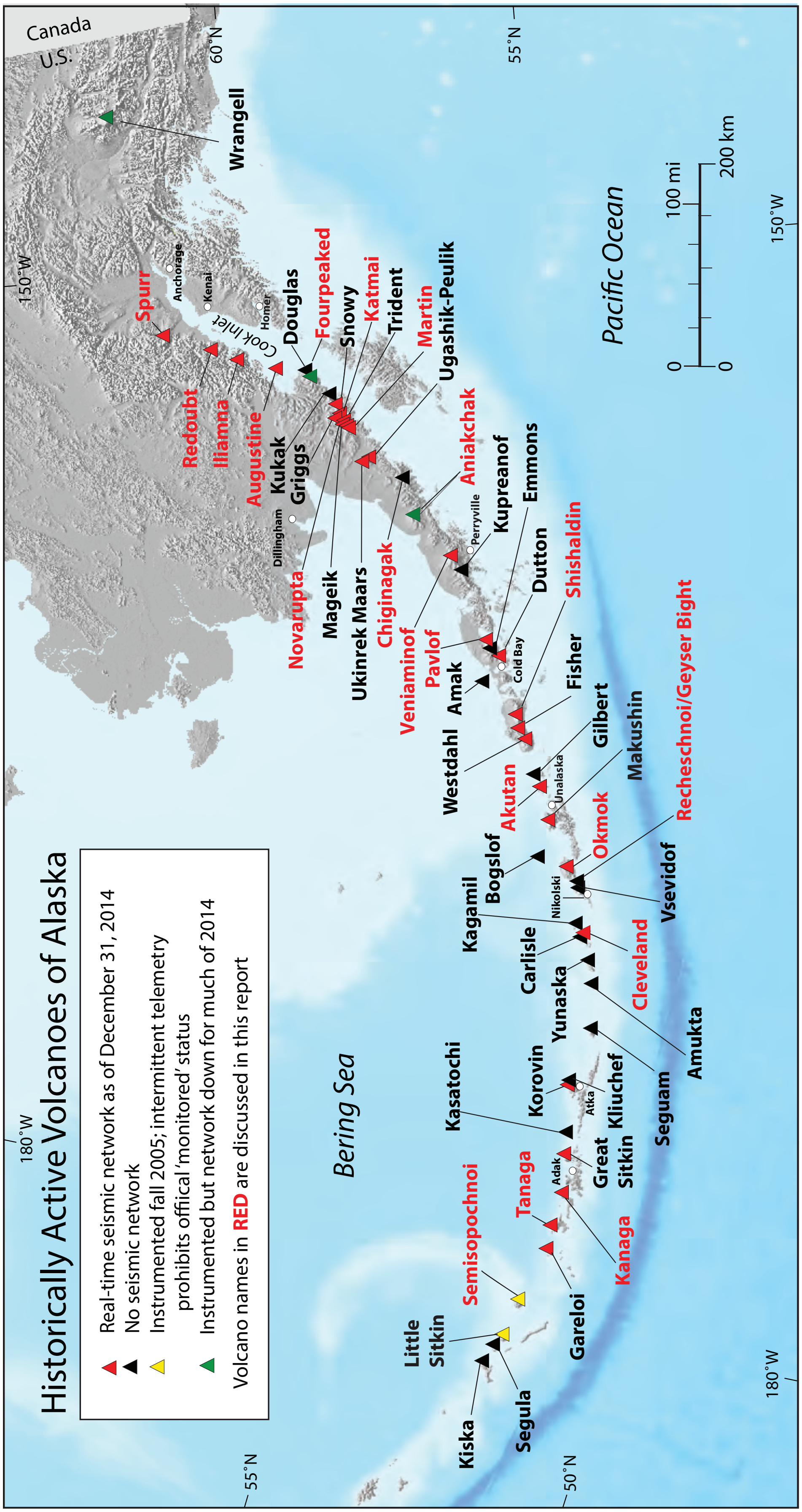

Figure 1. Map showing 52 historically active volcanoes in Alaska, their monitoring status, and place names used in this report. Following the established criteria and review of Cameron and others (2008), historically active volcanoes are considered those that have had an eruption or period of intense deformation, seismic or fumarolic activity that is inferred to reflect the presence of magma at shallow levels beneath the volcano. The "historical" period in Alaska is considered post-1750 when written records of volcanic activity began.

Table 1. Summary of 2014 volcanic activity in Alaska, including eruptions, possible eruptions, and unusual increases in seismicity or fumarolic activity.

[Cross-referenced lists of volcanic activity by year and by volcano for this and all previous Alaska Volcano Observatory annual activity reports are presented in tables 4 and 5. Location of volcanoes shown in figure 1]

Volcano	Date of activity (2014)	Type of activity
Spurr	June, September, and October	Earthquake swarm; outburst flood
Redoubt	Year-round	Web camera views of vapor plume
Iliamna	January, May, July, August, October	Rock and snow avalanche activity
Katmai Group	May, September, October	Resuspended 1912 ash
Martin	October, November	Earthquake swarm; vapor plume
Chiginagak	September	Increased fumarolic activity
Aniakchak	January	Seismic network failure
Veniaminof	Year-round	End of 2013 eruption
Pavlof	May–June; November	Two eruptions, with lava flows and tephra plumes
Shishaldin	Began at least by March, persisting into 2015	Intermittent low-level eruption, steam, and ash plumes
Akutan	July, December	Earthquake swarm; uplift; probable magmatic intrusion
Okmok	Year-round	Rapid inflation of the caldera
Geyser Bight and Recheshnoi	Year-round	Continuation of increased seismicity that began in 2013
Cleveland	Year-round, persisting into 2015	Small, ash-poor explosions and dome growth and destruction
Kanaga	March	Earthquake swarm
Tanaga	February–August	Earthquake swarm; likely magma intrusion with no eruption
Semisopochnoi	June	Earthquake swarm; likely magma intrusion with no eruption

The volcanoes discussed in this report are presented in geographic order from northeast to southwest along the Aleutian Arc. Each entry has a title block with the following information about the volcano—unique GVP identifier (where applicable); latitude, longitude, and summit elevation; geographic region; and an abbreviated summary highlighting volcanic activity. This is followed by a more detailed activity summary, often with accompanying tables, images, and illustrations. The event summary for each volcano ends by providing background information. The event summary is derived from published material as well as AVO daily and weekly updates, information releases, Volcano Activity Notices, AVO email and online electronic logs, and the Smithsonian Institution Global Volcanism Network Bulletins (available at http://www.volcano.si.edu/reports_bgvn.cfm). Beginning with the 2013 report, AVO's annual summary includes expanded information on seismicity and seismic networks at Alaska volcanoes.

Measurements are presented in International System of Units (SI) with approximate conversions to English or Inch/Pound Units in parentheses for convenience. Altitudes and elevations reported are in meters above sea level (ASL) and feet ASL in parentheses. Time is reported as Coordinated Universal Time (UTC) with the local time, Alaska Standard Time (AKST) or Alaska Daylight Time (AKDT), in parentheses. Volcano locations in latitude and longitude (presented in degrees and minutes rounded to the nearest minute) and summit elevations are taken from the Alaska Volcano Observatory database (World Geodetic System 1984 datum) and may differ slightly from previously published compilations.

Table 2. Alaska volcanoes with Aviation Color Code and Volcano Alert Level changes in 2014.

[Description of Aviation Color Codes is shown in appendix 1. Volcanoes that do not have a real-time seismic network are not assigned a color code **GREEN** because without seismic data, Alaska Volcano Observatory (AVO) has no definitive information that the level of activity at the volcano is at background. For these volcanoes, AVO uses the designation **UNASSIGNED**]

Color Code	Date of change
VENIAMINOF	
YELLOW/ADVISORY	January 1 – July 9
GREEN/NORMAL	July 9 – December 31
PAVLOF	
GREEN/NORMAL	January 1 – May 31
ORANGE/WATCH	May 31 – June 2
RED/WARNING	June 2 – June 3
ORANGE/WATCH	June 3 – June 25
YELLOW/ADVISORY	June 25 – July 30
GREEN/NORMAL	July 30 – November 12
ORANGE/WATCH	November 12 – November 15
RED/WARNING	November 15 – November 16
ORANGE/WATCH	November 16 – November 25
YELLOW/ADVISORY	November 25 – December 31
SHISHALDIN	
GREEN/NORMAL	January 1 – January 30
YELLOW/ADVISORY	January 30 – March 28
ORANGE/WATCH	March 28 – December 31
CLEVELAND	
YELLOW/ADVISORY	January 1 – January 2
ORANGE/WATCH	January 2 – January 10
YELLOW/ADVISORY	January 10 – December 31
SEMISOPOCHNOI	
UNASSIGNED	January 1 – June 13
YELLOW/ADVISORY	June 13 – September 4
UNASSIGNED	September 4 – December 31

What Is An “Eruption”?

The specific use of the term ‘eruption’ varies from scientist to scientist and there is no universally agreed-upon definition. Here, we adopt the usage of the Smithsonian Institution’s Global Volcanism Program, which defines eruptions as “…events that involve the explosive ejection of fragmental material, the effusion of liquid lava, or both” (Siebert and others, 2010). The elements of this definition that we wish to emphasize are the verbs ‘eject’ and ‘effuse,’ which refer to dynamic surface processes that pose some level of hazard. The presence or absence of often-ambiguous ‘juvenile material’ or fresh magma is not relevant to this use of the term eruption, particularly when communicating a potential hazard. This definition would not, however, include passive volcanic degassing or hydrothermal-fluid discharge.

What Is A “Historically Active Volcano”?

The AVO defines an “active” volcano as a volcanic center that has had a recent eruption (see “What is an ‘eruption’?”) or period of intense deformation, seismic or fumarolic activity that is inferred to reflect the presence of magma at shallow levels in the volcano. The “historical” period in Alaska is considered to start about 1750, when written records of volcanic activity began. Based on a rigorous re-analysis of all accounts of volcanic activity in Alaska from many sources, Cameron and others (2008) conclude that 52 Alaska volcanoes fit these criteria. This is a change from the oft-cited 41 of Miller and others (1998), and from previously published map compilations. As geologic understanding of Alaska’s volcanoes improves through additional fieldwork and modern radiometric-dating techniques, our list of “active” volcanoes will continue to evolve.

Table 3. History of seismic monitoring of Alaska volcanoes from August 1971 through December 2014.

[History of seismic monitoring compiled by J. Dixon. "First station installed" refers to the date when Alaska Volcano Observatory (AVO) first received real-time data from a permanent station. This date can be many months following initial fieldwork at the volcano. AVO considers the seismic network "complete" following installation and data transmission from a minimum of four seismic stations. Typically, AVO seismologists monitor the seismicity at the volcanic center for at least 6 months to understand background rates of seismicity before formally declaring a volcano seismically monitored and adding it to the monitored list. We note here the first mention of the seismic status of each monitored volcano in the AVO weekly update. Regularly issued written information statements began during the Redoubt eruption in 1989–90 and were expanded to include all Cook Inlet volcanoes in April 1991. The magnitude of completeness is the lowest magnitude earthquake that can confidently be located for activity at the volcanic center with an operational seismograph network. No magnitude of completion is calculated for Cleveland due to the lack of located seismicity. For more information on specific seismic network histories, readers are referred to the series of annual seismic summaries prepared by AVO (for example, Dixon and others, 2013). n/a, not applicable]

Volcano	Approximate start date of seismic monitoring	Earthquakes located in 2014	Magnitude of completeness
Wrangell	First station installed – July 2000 Network complete (4 stations) – **August 2001** Added to monitored list in weekly update – November 2001 Removed from monitored list in weekly update – January 27, 2012	0	0.9
Spurr	First station installed – August 1971 Network complete (17 stations) – **August 1989** Added to monitored list in weekly update – April 1991	609	0.2
Redoubt	First station installed – August 1971 Network complete (12 stations) – **August 1988** Added to monitored list in weekly update – April 1991	103	0.3
Iliamna	First station installed – September 1987 Network complete (7 stations) – **September 1994** Added to monitored list in weekly update – April 1991	32	-0.2
Augustine	First station installed – October 1976 Network complete (12 stations) – **August 1978** Added to monitored list in weekly update – April 1991	127	0.0
Fourpeaked	First station installed – September 2006 Network complete (4 stations) – **October 2006** Added to monitored list in weekly update – October 2006 Removed from monitored list in weekly update – November 2009	2	0.4
Katmai-North (Snowy)	First station installed – August 1988 Network complete (5 stations) – **October 199**8 Added to monitored list in weekly update – December 1998	132	0.8
Katmai-Central (Griggs, Katmai, Novarupta, Trident)	First station installed – August 1988 Network complete (7 stations) – **July 1991** Added to monitored list in weekly update – November 1996	308	0.4
Katmai-South (Martin, Mageik)	First station installed – August 1988 Network complete (8 stations) – **July 1996** Added to monitored list in weekly update – November 1996	397	0.3
Ukinrek Maars/ Peulik	First station installed – March 2005 Network complete (7 stations) – **March 2005** Added to monitored list in weekly update – April 2005	39	1.0
Aniakchak	First station installed – July 1997 Network complete (6 stations) – **July 1997** Added to monitored list in weekly update – November 1997 Removed from monitored list in weekly update – November 2009 Added to monitored list information statements – October 2015	0	1.4

Table 3. History of seismic monitoring of Alaska volcanoes from August 1971 through December 2014.—Continued

Volcano	Approximate start date of seismic monitoring	Earthquakes located in 2014	Magnitude of completeness
Veniaminof	First station installed – February 2002 Network complete (9 stations) – **February 2002** Added to monitored list in weekly update – September 2002 Removed from monitored list in weekly update – November 2009	24	1.5
Pavlof	First station installed – July 1996 Network complete (7 stations) – **July 1996** Added to monitored list in weekly update – November 1996	27	1.0
Dutton	First station installed – July 1988 Network complete (5 stations) – **July 1996** Added to monitored list in weekly update – November 1996	6	1.0
Shishaldin (and Isantoski)	First station installed – July 1997 Network complete (7 stations) – **July 1997** Shishaldin added to list in weekly update – November 1997 Isantoski added to list in weekly update – December 1998	23	0.6
Westdahl (and Fisher)	First station installed – August 1998 Network complete (6 stations) – **October 1998** Added to monitored list in weekly update – December 1998	12	1.1
Akutan	First station installed – March 1996 Network complete (13 stations) – **July 1996** Added to monitored list in weekly update – November 1996	297	0.4
Makushin	First station installed – July 1996 Network complete (8 stations) – **July 1996** Added to monitored list in weekly update – November 1996	420	0.7
Okmok	First station installed – January 2003 Network complete (13 stations) – **January 2003** Added to monitored list in weekly update – January 2004	78	0.9
Cleveland	First station installed – August 2014 Network complete (2 stations) – N/A Not yet added to monitored list in weekly update	1	n/a
Korovin	First station installed – July 2004 Network complete (7 stations) – **July 2004** Added to monitored list in weekly update – December 2005	283	1.2
Great Sitkin	First station installed – September 1999 Network complete (6 stations) – **September 1999** Added to monitored list in weekly update – December 1999	26	0.6
Kanaga	First station installed – September 1999 Network complete (6 stations) – **September 1999** Added to monitored list in weekly update – December 2000	146	1.2
Tanaga	First station installed – August 2003 Network complete (6 stations) – **August 2003** Added to monitored list in weekly update – June 2004	160	1.1
Gareloi	First station installed – August 2003 Network complete (6 stations) – **September 2003** Added to monitored list in weekly update – June 2004	6	1.2
Semisopochnoi (Cerberus)	First station installed – September 2005 Network complete (6 stations) – **September 2005** Not yet added to monitored list in weekly update	1,893	0.5
Little Sitkin	First station installed – September 2005 Network complete (4 stations) – **September 2005** Not yet added to monitored list in weekly update	42	0.0

Table 4. Compilation by year of Alaska volcanoes included in an Alaska Volcano Observatory Annual Summary, 1992–2014.

[Volcanoes are presented in geographical order from northeast to southwest along the Wrangell-Aleutian volcanic arc]

Volcanoes mentioned	
Alaskan	**Russian**
1992	
Spurr/Crater Peak	
Iliamna	
Redoubt	
Mageik (Katmai Group)	
Westdahl	
Akutan	
Bogoslof	
Seguam	
1993	
Churchill	
Sanford	
Spurr/Crater Peak	
Veniaminof	
Shishaldin	
Makushin	
Seguam	
Kliuchef (Atka)	
Kanaga	
1994	
Sanford	
Iliamna	
Katmai Group (Martin, Mageik, Trident)	
Veniaminof	
Kupreanof	
Shishaldin	
Makushin	
Cleveland	
Kanaga	
1995	
Katmai Group (Martin)	Bezymianny
Veniaminof	Karymsky
Shishaldin	
Makushin	
Kliuchef (Atka)	
Kanaga	
1996	
Wrangell	Klyuchevskoy
Iliamna	Bezymianny
Katmai Group (Martin, Mageik, Trident, Katmai)	Karymsky
	Avachinsky
	Mutnovsky
Pavlof	Alaid (Kurile Islands)
Shishaldin	
Westdahl	
Akutan	
Amukta	
Korovin (Atka)	
Kanaga	
1997	
Wrangell	Sheveluch
Sanford	Klyuchevskoy
Shrub Mud	Bezymianny
Iliamna	Karymsky
Katmai Group (Martin, Mageik, Snowy, Kukak)	Alaid (Kurile Islands)
Chiginagak	
Pavlof	
Shishaldin	
Okmok	
Cleveland	
Amukta	
1998	
Shrub Mud	Sheveluch
Augustine	Klyuchevskoy
Becharof Lake	Bezymianny
Chiginagak	Karymsky
Shishaldin	
Akutan	
Korovin (Atka)	
1999	
Wrangell	Sheveluch
Shrub Mud	Klyuchevskoy
Iliamna	Bezymianny
Veniaminof	Karymsky
Pavlof	
Shishaldin	
Vsevidof	
2000	
Wrangell	Sheveluch
Katmai Group (Snowy)	Klyuchevskoy
Chiginagak	Bezymianny
Shishaldin	Karymsky
	Mutnovsky
2001	
Katmai Group (Snowy/Kukak)	Sheveluch
	Klyuchevskoy
Pavlof	Bezymianny
Frosty	Karymsky
Shishaldin	Avachinsky
Makushin	
Okmok	
Cleveland	
Great Sitkin	

Table 4. Compilation by year of Alaska volcanoes included in an Alaska Volcano Observatory Annual Summary, 1992–2014.—Continued

[Volcanoes are presented in geographical order from northeast to southwest along the Wrangell-Aleutian volcanic arc]

Volcanoes mentioned	
Alaskan	**Russian**
2002	
Wrangell Katmai Group (Martin, Mageik) Veniaminof Mt. Hague (Emmons Lake Caldera) Shishaldin Great Sitkin	Sheveluch Klyuchevskoy Bezymianny Karymsky
2003	
Wrangell Redoubt Iliamna Augustine Katmai Group (Mageik) Veniaminof Pavlof Mt. Hague (Emmons Lake Caldera) Shishaldin Akutan	Sheveluch Klyuchevskoy Bezymianny Karymsky Alaid (Kurile Islands) Chikurachki (Kurile Islands)
2004	
Crillon (non-volcanic peak) Spurr Katmai Group (Martin) Veniaminof Shishaldin Westdahl	Sheveluch Klyuchevskoy Bezymianny Karymsky Chirinkotan (Kurile Islands)
2005	
Spurr Iliamna Augustine Katmai Group (Martin, Mageik, Trident) Chiginagak Aniakchak Veniaminof Pavlof/Hague Shishaldin Cleveland Korovin Kasatochi Tanaga	Sheveluch Klyuchevskoy Bezymianny Karymsky Avachinsky Mutnovsky Ebeko (Kurile Islands) Chikurachki (Kurile Islands)

Volcanoes mentioned	
Alaskan	**Russian**
2006	
Klawasi Spurr Augustine Fourpeaked Katmai Group (Martin, Mageik, Trident) Veniaminof Cleveland Korovin Kasatochi	Sheveluch Klyuchevskoy Bezymianny Karymsky Ebeko Severgin Berga
2007	
Redoubt Augustine Fourpeaked Veniaminof Pavlof Akutan Cleveland Korovin	Sheveluch Klyuchevskoy Bezymianny Karymsky Gorely and Mutnovsky Chikurachki Berga
2008	
Redoubt Aniakchak Veniaminof Shishaldin Okmok Cleveland Kasatochi	Sheveluch Klyuchevskoy Bezymianny Karymsky Koryaksky Gorely and Mutnovsky Chikurachki Tyatya
2009	
Sanford Redoubt Fourpeaked Aniakchak Veniaminof Shishaldin Okmok Cleveland	Sheveluch Klyuchevskoy Bezymianny Kizimen Karymsky Koryaksky Gorely Ebeko Sarychev Raikoke

Table 4. Compilation by year of Alaskan volcanoes included in an Alaska Volcano Observatory Annual Summary, 1992–2014.—Continued

[Volcanoes are presented in geographical order from northeast to southwest along the Wrangell-Aleutian volcanic arc]

Volcanoes mentioned	
Alaskan	**Russian**
2010	
Wrangell	Sheveluch
Sanford	Klyuchevskoy
Redoubt	Bezymianny
Fourpeaked	Kizimen
Katmai Group	Karymsky
Becharof Lake	Gorely
Aniakchak	Ekarma
Veniaminof	
Westdahl	
Makushin	
Cleveland	
Kasatochi	
2011	
Wrangell	
Sanford	
Redoubt	
Fourpeaked	
Aniakchak	
Veniaminof	
Makushin	
Westdahl	
Cleveland	
Kasatochi	
2012	
Wrangell	
Spurr	
Redoubt	
Iliamna	
Augustine	
Fourpeaked	
Katmai Group (Martin)	
Aniakchak	
Cleveland	
Kanaga	
Little Sitkin	

Volcanoes mentioned	
Alaskan	**Russian**
2013	
Wrangell	
Redoubt	
Iliamana	
Augustine	
Fourpeaked	
Peulik	
Aniakchak	
Veniaminof	
Pavlof	
Shishaldin	
Akutan	
Makushin	
Okmok	
Cleveland	
Atka (Korovin)	
Great Sitkin	
Gareloi	
2014	
Spurr	
Redoubt	
Iliamna	
Fourpeaked	
Katmai Group (Katmai/ Novarupta)	
Martin	
Chiginagak	
Aniakchak	
Veniaminof	
Pavlof	
Shishaldin	
Akutan	
Okmok	
Geyser Bright and Recheshonoi	
Cleveland	
Kanaga	
Tanaga	
Semisopochnoi	

Table 5. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2014.

[Volcanic centers are listed from the most eastern volcanic center to the westernmost. Suspect Volcanic Activity (SVA) is defined as a report of eruption or possible eruption that is normal fumarolic activity or non-volcanic phenomena, such as weather related. PIREP, pilot weather report]

Volcano	Year mentioned	Type of activity
Churchill	1993	SVA, anomalous seismicity
Wrangell	1996	SVA, steam plume
	1997	SVA, steam plume
	1999	SVA, steaming and phreatic ash emission
	2000	SVA, steam plumes
	2002	SVA, suspicious clouds, redistributed ash
	2003	SVA, anomalous clouds
	2007	Triggered seismicity, vapor clouds, wind-blown ash
	2010	Anomalous clouds
	2012	Anomalous clouds
	2013	SVA, redistributed ash, fumarolic activity
Sanford	1993	SVA, reported steam plume likely from avalanche
	1994	SVA, reported steam plume likely from avalanche
	1997	SVA, large steam cloud from southwest face
	2009	Persistent anomalous clouds
	2010	Anomalous cloud from southwest face
Shrub Mud	1997	Eruption; energetic ejection of saline mud and CO_2
	1998	Eruption continues; ejection of saline mud and CO_2
	1999	Eruption continues; ejection of saline mud and CO_2
Klawasi Mud	2006	Possible new mud vent
Spurr	1992	Subplinian eruptions; ash, pyroclastic flows, lahars
	1993	SVA, glacial outburst produces seismicity
	2004	Heat flux to summit; lahars; cauldron develops
	2005	Continued heat to summit; cauldron evolves
	2006	Continued heat to summit; cauldron evolves
	2012	Glacial outburst flood
	2014	Fumarolic plume
Redoubt	1992	SVA, steam plume from still-cooling dome
	2003	SVA, anomalous weather cloud
	2007	Possible steaming and increased thermal flux
	2008	Increased gas and thermal flux
	2009	Major magmatic eruption, domes, lahars, ash fall
	2010	Vapor and gas clouds; brief uptick in seismicity
	2012	Degassing, robust fumarolic plume
	2013	Degassing, fumarolic plume
	2014	Fumarolic plume
Iliamna	1992	SVA, PIREP of large steam plume, media frenzy
	1994	SVA, vigorous steam plume, avalanche
	1996	Intense seismicity related to magmatic intrusion
	1997	SVA; anomalous seismic swarm; avalanche
	1999	SVA, avalanche
	2003	SVA, avalanche
	2005	SVA, rock avalanche
	2012	Fumarolic plume, seismic swarms, avalanches
	2013	SVA, increased steaming, avalanches
	2014	Avalanches
Augustine	1998	1986 dome spine partially collapses, generates mudflow
	2005	Precursory activity prior to eruption in early 2006
	2006	Explosive and effusive eruption
	2007	Strong seismicity and steam plumes
	2012	Fumarolic plumes, sulfur odor, seismicity

Table 5. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2014.—Continued

Volcano	Year mentioned	Type of activity
Fourpeaked	2006	Phreatic eruption
	2007	Ongoing fumarolic emissions, seismicity
	2009	Continued decline in gas emissions
	2010	Decreasing fumarolic emissions, sporadic earthquake swarms
	2012	Increased seismicity
	2013	Increased seismicity, anomalous plume
Katmai Group		
Mageik	1992	SVA, anomalous cloud
Martin/Mageik/Trident	1994	SVA, plume-like cloud
Martin	1995	SVA, large steam plume
Martin/Mageik/Trident/Katmai	1996	SVA, anomalous seismicity
Martin/Mageik/Snowy/Kukak	1997	SVA, PIREPS of ash and steam plumes
Snowy	2000	SVA, steaming hole in glacier
Snowy/Kukak	2001	SVA, steaming hole in glacier
Martin/Mageik	2002	SVA, steam plume
Mageik	2003	SVA, steaming, large cloud of re-suspended ash
Martin	2004	SVA, large steam plume
Martin/Mageik/Trident	2005	SVA, steam cloud, resuspended ash
Martin	2006	Earthquake swarm
Martin	2010	Resuspended ash
Martin	2012	Elevated seismicity, fumarolic plumes
Katmai/Novarupta/Martin	2014	Resuspended 1912 ash; Earthquake swarm, vapor plume
Becharof Lake	1998	SVA, intense seismic swarm and inflationary episode
	2010	Earthquake swarm
Ugashik-Peulik	2013	SVA, reported steaming, sulfur odors
Chiginagak	1997	Minor eruptive activity, new fumarole field
	1998	SVA, continuation of increased fumarolic activity
	2000	SVA, steam emissions from fumarole field
	2005	Heat to summit; acidic flood; cauldron develops
	2014	Fumarolic activity
Aniakchak	2005	SVA, anomalous seismicity, thermal anomaly
	2008	Weather related noise on seismic stations
	2009	Anomalous seismicity
	2010	Low frequency earthquake swarms
	2011	Anomalous seismicity
	2012	Increased seismicity, possible tremor
	2013	Short seismic swarms
Veniaminof	1993	Low-level eruption and lava flows
	1994	Strombolian eruption and lava flows
	1995	Strombolian eruptions
	1999	SVA, extreme discharge and turbid river
	2002	Low-level phreatic eruptions
	2003	Low-level phreatic eruptions
	2004	Weak phreatic and Strombolian eruption
	2005	Intermittent phreatic and Strombolian eruption
	2006	Intermittent phreatic and Strombolian eruption
	2007	Decline in vapor plumes
	2008	Weak phreatic emissions and vapor plumes
	2009	Minor phreatic eruptions, sporadic
	2010	Sporadic seismicity, vapor plumes
	2013	Effusive eruption
	2014	End of 2013 eruption
Kupreanof	1994	SVA, PIREP of unusual steam plume

Table 5. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2014.—Continued

Volcano	Year mentioned	Type of activity
Pavlof	1996	Strombolian eruption
	1997	Strombolian eruption concludes
	1999	SVA, summit snow melt, ash dustings, steam plumes
	2001	SVA, steaming, possible ash, sulfur smell
	2005	SVA, mis-located steam plume
	2007	Strombolian eruption, lava flows, lahars
	2012	Tremor burst, fumarolic plume
	2013	Strombolian eruption
	2014	Two Strombolian eruptions
Hague (Emmons Lake Caldera)	2002	SVA, increase in fumarolic activity in summit crater
	2003	SVA, crater lake drains, refills, drains
	2005	SVA, steam plume
Frosty	2001	SVA, rock fall avalanches
Shishaldin	1993	Minor phreatic activity?
	1994	SVA, PIREP of minor steam/ash
	1995	Minor eruptive activity, steam/ash
	1996	Eruption; steam/ash and thermal anomaly
	1997	Minor eruptive activity, steam/ash
	1998	Minor eruptive activity, steam/ash
	1999	Strombolian eruption
	2000	Minor eruptive activity, steam/ash
	2001	Minor unrest, seismicity increase, steam clouds
	2002	SVA, shallow seismicity; PIREP of possible eruption
	2003	SVA, steam plumes
	2004	Small steam and ash plumes
	2005	SVA, increased seismicity, steam plumes prompt PIREPS
	2008	Minor phreatic (?) ash emission and vigorous vapor plumes
	2009	Increased seismicity, small steam and ash plume, thermal anomalies
	2013	Seismicity, small steam plume
	2014	Low-level eruption
Westdahl	1992	Fissure eruption, lava fountains, ash clouds, lava flow
	1996	SVA, suspicious weather cloud on satellite image
	2004	SVA, seismic swarm
	2010	Increase in lower crustal seismicity
Akutan	1992	SVA, steam/ash emissions
	1996	Intensive seismicity, ground cracking
	1998	SVA, tremor-like seismicity
	2003	SVA, anomalous steam plume
	2007	Triggered seismicity; inflation; anomalous steaming
	2013	Triggered seismicity, intermittent tremor
	2014	Earthquake swarm; uplift; probable magmatic inflation
Makushin	1993	Minor phreatic
	1994	SVA, PIREP of minor steam/ash
	1995	SVA, steam plume
	2001	SVA, increase in seismicity
	2008	Discolored seawater in Unalaska Bay
	2010	Seismicity, anomalous clouds reported
	2013	Intermittent tremor, small steam plume
Bogoslof	1992	Dome extrusion, ash and steam emissions

Table 5. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2014.—Continued

Volcano	Year mentioned	Type of activity
Okmok	1997	Strombolian eruption
	2001	SVA, seismic swarm
	2008	Major Phreatomagmatic eruption
	2009	Bursts of tremor, inflation
	2011	Inflation
	2013	Sporatic tremor, inflation, earthquake swarm
	2014	Inflation
Vsevidof	1999	SVA, sighting of ash after regional earthquake
Cleveland	1994	SVA, possible steam/ash emission
	1997	Minor eruption, steam/ash
	2001	Eruption; gas/ash, lava/debris flows
	2005	Intermittent explosions
	2006	Intermittent explosions
	2007	Intermittent explosions, small ash clouds, ballistics
	2008	Intermittent explosions; small ash clouds
	2009	Thermal anomalies, minor ash and gas emissions, flowage and ballistics deposits
	2010	Explosions, small ash clouds, vapor plumes, thermal anomalies
	2011	Intermittent explosions, small ash clouds
	2012	Thermal anomalies, intermittent explosions, small ash clouds
	2013	Lava extrusion, explosions, small ash clouds
	2014	Low-level eruption
Amukta	1996	Small eruption; ash emission
	1997	SVA, PIREP of small ash eruption
Seguam/Pyre Peak	1992	Minor eruptive activity, steam/ash emissions
	1993	Fissure eruption produces lava flow and ash cloud
Atka		
Kliuchef	1993	SVA, audible rumbling, strong sulfur odor
Kliuchef	1995	SVA, large steam plume, strong sulfur odor
Korovin	1996	SVA, PIREP of ash cloud, suspicious cloud on satellite image
Korovin	1998	Eruption; explosions and ash fall
Korovin	2005	Minor eruption, steam and ash
Korovin	2006	Seismic swarms, uplift, increased fumarolic activity
Korovin	2007	Seismic swarms; fumarolic activity
Korovin	2013	Earthquake swarms, intermittent tremor
Kasatochi	2005	SVA, unusual bubbling; floating scum on crater lake
	2006	Continued bubbling in intracaldera lake
	2008	Major explosive eruption
	2009	Summit lake level rise
	2010	Fumarolic emission, diffuse degassing, coastal erosion
Great Sitkin	2001	SVA, anomalous seismicity
	2002	SVA, seismic swarm, tremor
	2013	Earthquake swarms
Kanaga	1993	SVA, increased steaming
	1994	Eruption; steam/ash and lava flow
	1995	Minor eruptive activity, steam/ash and lava
	1996	Possible eruption and ash emission
	2012	Phreatic (?) explosion, limited ash fall, new summit fissure
	2014	Earthquake swarm
Gareloi	2013	SVA reported steaming, felt earthquakes, anomalous seismicity, including a period of tremor

Table 5. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2014.—Continued

Volcano	Year mentioned	Type of activity
Tanaga	2005	SVA, anomalous seismicity, including a period of tremor
	2014	Earthquake swarm
Little Sitkin	2012	Seismic swarms, likely magmatic intrusion
Semisopochnoi	2014	Earthquake swarm; likely magmatic intrusion

Table 6. Citations for Alaska Volcano Observatory Annual Summary reports, 1992–2013.

Year	Citation	URL
1992	McGimsey, R.G., Neal, C.A., and Doukas, M.P., 1995, Volcanic activity in Alaska: Summary of events and response of the Alaska Volcano Observatory, 1992: U.S. Geological Survey Open-File Report 95-83, 26 p.	http://pubs.er.usgs.gov/publication/ofr9583/
1993	Neal, C.A., McGimsey, R.G., and Doukas, M.P., 1996, Volcanic activity in Alaska: Summary of events and response of the Alaska Volcano Observatory, 1993: U.S. Geological Survey Open-File Report 96-24, 21 p.	http://pubs.usgs.gov/of/1996/0024/
1994	Neal, C.A., Doukas, M.P., and McGimsey, R.G., 1995, 1994 Volcanic activity in Alaska: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 95-271, 20 p.	http://pubs.usgs.gov/of/1995/0271/
1995	McGimsey, R.G., and Neal, C.A., 1996, 1995 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 96-738, 22 p.	http://pubs.usgs.gov/of/1996/0738/
1996	Neal, C.A., and McGimsey, R.G., 1997, 1996 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 97-433, 34 p.	http://pubs.usgs.gov/of/1997/0433/
1997	McGimsey, R.G., and Wallace, K.L., 1999, 1997 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 99-448, 42 p.	http://pubs.usgs.gov/of/1999/0448/
1998	McGimsey, R.G., Neal, C.A., and Girina, Olga, 2004, 1998 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 03-423, 35 p.	http://pubs.usgs.gov/of/2003/of03-423/
1999	McGimsey, R. G., Neal, C. A., and Girina, Olga, 2004a, 1999 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1033, 49 p.	http://pubs.usgs.gov/of/2004/1033/
2000	Neal, C.A., McGimsey, R.G., and Chubarova, Olga, 2004, 2000 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1034, 37 p.	http://pubs.usgs.gov/of/2004/1034/
2001	McGimsey, R.G., Neal, C.A., and Girina, Olga, 2004b, 2001 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1453, 53 p.	http://pubs.usgs.gov/of/2004/1453/
2002	Neal, C.A., McGimsey, R.G., and Girina, Olga, 2005, 2002 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1058, 55 p.	http://pubs.usgs.gov/of/2004/1058/

Table 6. Citations for Alaska Volcano Observatory Annual Summary reports, 1992–2013.—Continued

Year	Citation	URL
2003	McGimsey, R.G., Neal, C.A., and Girina, Olga, 2005, 2003 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2005-1310, 62 p.	http://pubs.usgs.gov/of/2005/1310/
2004	Neal, C.A., McGimsey, R.G., Dixon, J.P., and Melnikov, Dmitry, 2005, 2004 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2005-1308, 71 p.	http://pubs.usgs.gov/of/2005/1308/
2005	McGimsey, R.G., Neal, C.A., Dixon, J.P., Ushakov, Sergey, 2007, 2005 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2007-5269, 94 p.	http://pubs.usgs.gov/sir/2007/5269/
2006	Neal, C.A., McGimsey, R.G., Dixon, J.P., Manevich, Alexander, and Rybin, Alexander, 2009, 2006 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2008-5214, 102 p.	http://pubs.usgs.gov/sir/2008/5214/
2007	McGimsey, R.G., Neal, C.A., Dixon, J.P., Malik, Nataliya, and Chibisova, Marina, 2011, 2007 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2010–5242, 110 p.	http://pubs.usgs.gov/sir/2010/5242/
2008	Neal, C.A., McGimsey, R.G., Dixon, J.P., Cameron, C.E., Nuzhdaev, A.E., and Chibisova, M., 2011, 2008 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2010–5243, 94 p.	http://pubs.usgs.gov/sir/2010/5243/
2009	McGimsey, R.G., Neal, C.A., Girina, O.A., Chibisova, Marina, and Rybin, Alexander, 2013, 2009 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2013–5213, 125 p.	http://pubs.usgs.gov/sir/2013/5213/
2010	Neal, C.A., Herrick, J., Girina, O.A., Chibisova, M., Rybin, A., McGimsey, R., and Dixon, J., 2014, 2010 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2014-5034, 76 p.	http://pubs.usgs.gov/sir/2014/5034/
2011	McGimsey, R.G., Maharrey, J. Z., and Neal, C.A., 2014, 2011 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2014–5159, 50 p.	http://pubs.usgs.gov/sir/2014/5159/
2012	Herrick, J.A., Neal, C.A., Cameron, C.E., Dixon, J.P., and McGimsey, R.G., 2014, 2012 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2014–5160, 82 p.	http://pubs.usgs.gov/sir/2014/5160/
2013	Dixon, J.P., Cameron, Cheryl, McGimsey, R.G., Neal, C.A., and Waythomas, Chris, 2015, 2013 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2015–5110, 92 p.	http://dx.doi.org/10.3133/sir20155110

Volcanic Activity In Alaska, Northeast to Southwest Along Aleutian Arc

Mount Spurr

GVP # 313040

61°18'N 152°15'W
3,374 m (11,070 ft)

Cook Inlet

EARTHQUAKE SWARM; OUTBURST FLOOD EVENT

During 2014, the Aviation Color Code and Volcano Alert Level for Mount Spurr remained **GREEN/NORMAL** throughout the year, although AVO did note periods of anomalous seismicity and a probable glacial outburst flood.

A swarm of low-frequency earthquakes began in early June, following a M3.8 earthquake 13 km (8 mi) west of Mount Spurr. A total of 300 earthquakes were located in this swarm, which ended in mid-October. A swarm in the same area occurred in late 2012. The cause of the swarm remains undetermined. In 2004, seismicity, surface heat flux, and gas emissions suggested a magmatic intrusion (Power, 2004; Neal and others, 2005; Coombs and others, 2006).

At 20:20 UTC (11:20 a.m. AKDT) on September 10, the Spurr seismograph network recorded a signal interpreted by AVO seismologists as a glacial outburst flood (fig. 2). The flow appears as a single event lasting about 20 minutes. Similar events, but of longer duration, have been recorded at Mount Spurr on several occasions, most recently in 2012 (Herrick and others, 2014). AVO was unable to visually confirm the inferred outburst event.

Mount Spurr is a 3,374-m high (11,070-ft) ice- and snow-covered stratovolcano located 125 km (80 mi) west of Anchorage. Explosive historical eruptions occurred in 1953 and 1992 from Crater Peak, a satellite vent 3.5 km (2 mi) south of the Mount Spurr summit (Keith, 1995, and references therein). Each of these eruptions produced ashfalls that impacted populated areas of south-central Alaska. Mount Spurr's largely ice-covered edifice may be a lava dome complex (Nye and Turner, 1990). The last known significant eruption from the summit, based on correlation of tephra deposits, was about 5,200 years ago (Riehle, 1985), although there are many smaller eruptions since 5,200 (Kristi Wallace, USGS/AVO, written commun., 2016).

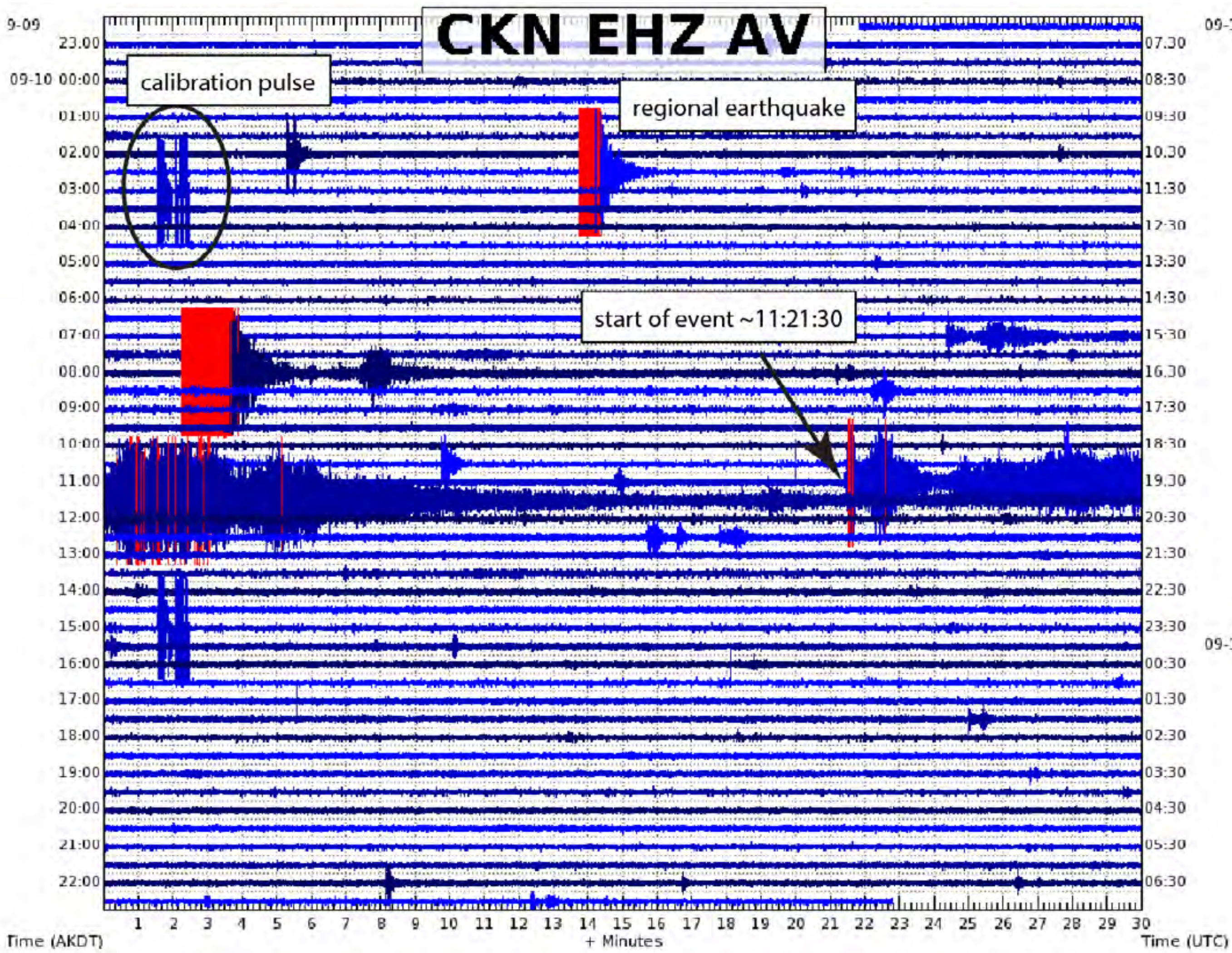

Figure 2. Annotated 24-hour webicorder display for seismic station CKN at Mount Spurr, September 10, 2014. During a daily check of seismic data, AVO noted the protracted, sudden onset signal that occurred just after 11:21 a.m. AKDT. This was a likely outburst of water from beneath one of the glaciers on the southern flank of Mount Spurr. AVO seismologists have noted other examples of this type of long-duration signal when high-discharge events have been observed in the field. Note how different this appears from a typical regional earthquake (at top) and the twice-daily station calibration pulses (e.g., upper left). AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=67731.

Redoubt Volcano

GVP # 313030

60°29'N 152°45'W
3,108 m (10,197 ft)

Cook Inlet

WEB CAMERA VIEWS OF VAPOR PLUME

Activity related to cooling and continued degassing of the lava dome extrude in 2009 on Redoubt Volcano prompted citizen attention on clear days. Web camera views on clear days throughout 2014 often showed a white vapor plume (fig. 3). A gas flight over Redoubt on April 10 measured several hundred tons per day of sulfur dioxide (SO_2)—similar to that measured in 2013 (Cynthia Werner, USGS/AVO, written commun., 2015).

Heavily ice-mantled Redoubt Volcano is located on the western side of Cook Inlet, 170 km (106 mi) southwest of Anchorage and 82 km (51 mi) west of Kenai, within Lake Clark National Park and Preserve. Historical eruptions occurred in 1902, 1966–68, 1989–90, and 2009 (Waythomas and others, 1997; Schaefer, 2011; McGimsey and others, 2014). The 1989–90 and 2009 eruptions produced lahars (volcanic mudflows) that traveled down the Drift River drainage and partially flooded the Drift River Oil Terminal facility. The 1966–68 eruption also sent lahars down the Drift River drainage. Ash clouds produced by the 1989–1990 and 2009 eruptions affected air traffic and resulted in minor or trace amounts of ash on communities in south-central Alaska (Miller and Chouet, 1994; Schaefer, 2011).

Figure 3. Web camera view looking south of the Redoubt summit from AVO's Redoubt Hut webcam, an instrumentation trailer on the ridge just north of the volcano, February 10, 2014. Optimal atmospheric conditions and clear weather produced this view of a steam plume at Redoubt, due to the still-cooling 2009 lava dome. Steam from Redoubt was a common sight during 2014. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=57731.

Iliamna Volcano

GVP # 313020

60°02'N 153°05'W
3,053 m (10,016 ft)

Cook Inlet

AVALANCHE ACTIVITY

As in previous years, Iliamna Volcano during 2014 experienced several significant rock/snow/ice avalanches on its eastern flank, and numerous smaller avalanches. Seismic data indicated a likely avalanche at 12:11 UTC (3:11 a.m. AKST) on January 28. This event was identified primarily by its characteristic seismicity—precursory seismicity of small, discrete events transitioning into a continuous signal consistent with a slide (Scott Stihler, UAFGI/AVO, written commun., 2014). In mid-May, satellite imagery of Iliamna showed recent avalanche deposits extending about 1.5 km (0.93 mi) eastward from a near-summit source area (Christina Neal, USGS/AVO, written commun., 2014) that may have been the source of the seismic signal 4 months earlier.

AVO conducted its annual overflight of Iliamna to measure gas concentrations on April 10, recording normal background levels of about 32 tons/d of SO_2. Because of an instrument malfunction, CO_2 was not measured on this flight (Cynthia Werner, USGS/AVO, written commun., 2015). Iliamna remained at Aviation Color Code and Volcano Alert Level **GREEN/NORMAL** throughout 2014.

On July 20, AVO received a phone call from a citizen on the Kenai Peninsula reporting a new avalanche at Iliamna, identified by the presence of new dark streaks within the snowfield. A review of the seismic data showed that the avalanche likely occurred at about 16:00 UTC (8:00 a.m. AKDT) on July 20 (fig. 4). The deposit extended about 2.8 km (1.7 mi) east from the summit (Rick Wessels, USGS/AVO, written commun., 2014).

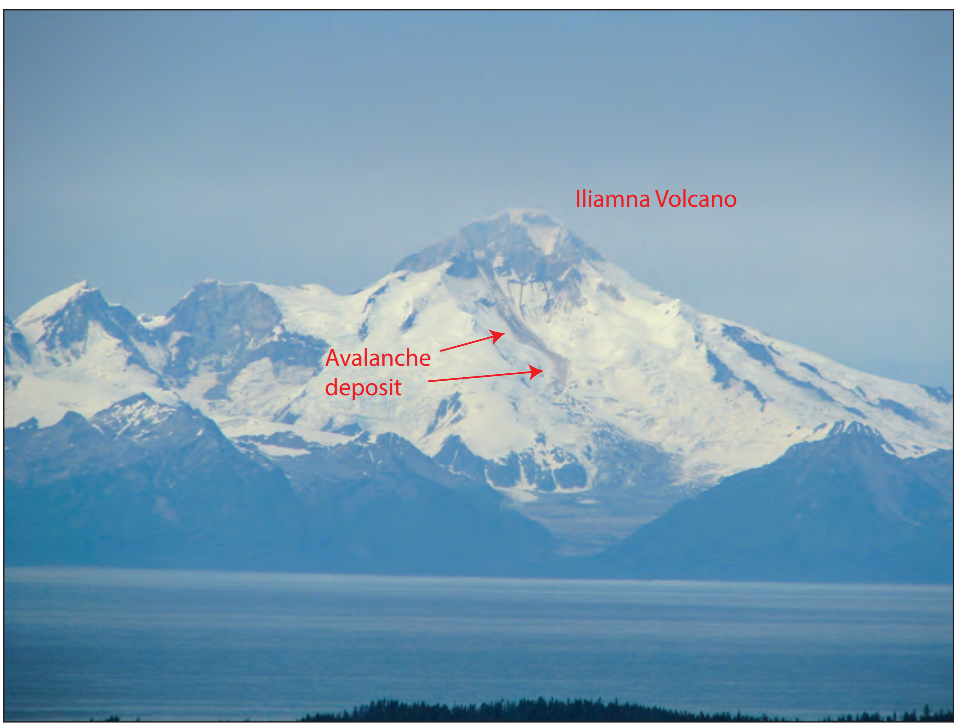

Figure 4. Fresh rockfall/avalanche on eastern side of Iliamna Volcano, as viewed from the Kenai Peninsula, July 21, 2014. Location of rockfall/avalanche shown by arrows. Photograph by Dennis Anderson, used with permission. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=66671.

Satellite imagery from August 19 documented new fresh avalanches at Iliamna, slightly larger than those in July. In early October, AVO observed evidence for a small, recent landslide or avalanche on the upper headwall of the Red Glacier on the eastern side of Iliamna. A retrospective analysis of the seismic data showed that the avalanche likely occurred in the early morning of October 3 (Jacqueline Caplan-Auerbach, Western Washington University, written commun., 2014). This new avalanche extended about 2 km (1.2 mi) from its source area (fig. 5).

Iliamna Volcano is a little studied glacier-carved stratovolcano located about 215 km (134 mi) southwest of Anchorage on the western side of lower Cook Inlet. Although there are no known historical eruptions, geologic studies document late Holocene explosive activity as well as repeated, significant mass wasting of the steep, hydrothermally altered edifice (Waythomas and Miller, 1999). Fumaroles located at about an elevation of 2,740 m (8,990 ft) ASL on the eastern flank produce plumes of steam condensate and volcanic gas almost continuously (Werner and others, 2011). In the past two decades, at least two magmatic intrusions have occurred beneath Iliamna (Roman and others, 2004; Prejean and others, 2012).

Figure 5. Web camera views before and after a small rockfall/landslide on Iliamna Volcano. Top image: View from IVE Web camera on October 2, before rockfall. Bottom image: View from IVE Web camera on October 3, after the rockfall (circled in red). The debris flowed about 2 km (1.2 mi) down the upper Red Glacier. The slide occurred early on October 3, 2014. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=77461.

Fourpeaked Mountain

GVP # 312260

58°46'N 153°40'W
2,104 m (6,903 ft)

Cook Inlet/Alaska Peninsula

FAILURE OF SEISMIC MONITORING NETWORK

In early 2014, all monitoring instruments at Fourpeaked Mountain failed, preventing seismic monitoring of the volcano. Consequently, AVO removed Fourpeaked from the list of seismically monitored volcanoes on February 7 and assigned an Aviation Color Code and Volcano Alert Level as **UNASSIGNED**. Seismic stations on Fourpeaked were not restored during 2014.

Fourpeaked is a little studied, deeply glaciated stratocone that experienced a phreatic eruption in 2006 (Neal and others, 2009). AVO is aware of one report of possible increased fumarolic output in summer 1965. Although the range of sizes and styles of past eruptions is not well constrained, past eruptions of andesite and dacite indicate that eruptions at Fourpeaked can be explosive, possibly producing plumes that reach an altitude in excess of 10 km (33,000 ft) ASL (J. Fierstein, USGS, oral commun., 2006). Fourpeaked lies in the northeastern corner of Katmai National Park and Preserve on the Alaska Peninsula, 12 km (7.5 mi) southwest of Mount Douglas.

Katmai Group (Novarupta)

GVP # 312180

58°16'N 155°10'W
841 m (2,759 ft)

Alaska Peninsula

RESUSPENDED ASH FROM 1912 NOVARUPTA ERUPTION

Resuspension and transport of fine-grained volcanic ash from the Katmai National Park and Preserve region of Alaska frequently have been observed and documented for decades (Hadley and others, 2004; McGimsey and others, 2005), and five episodes of resuspended ash were documented in 2014. The 1912 eruption of Novarupta deposited large quantities of ash in valleys of the Katmai area, and the landscape remains desolate and largely vegetation-free, even more than a century later. During times of no snow and strong northwesterly winds, the ash can be resuspended and transported southeast across Shelikof Strait, Kodiak Island, and the Gulf of Alaska. These events commonly are identified by the presence of ash blowing from the Katmai area, often detected in satellite imagery, coupled with existing high winds and a lack of other volcanic signals (no thermal anomalies, no increased seismicity).

On May 19, flights to Karluk on Kodiak Island were delayed because of weather conditions and a visible plume of resuspended ash originating from the Katmai area. The ash was weakly visible in satellite imagery, and strong northwesterly winds were blowing from the Katmai area towards the southeast. The National Weather Service Alaska Aviation Weather Unit (NWS AAWU) issued a Special Weather Statement. The NWS AAWU also issued SIGnificant METeorological information statements (SIGMETs) for resuspended Katmai ash due to strong winds on September 29 and October 5, when ash again was visible in satellite imagery blowing toward Kodiak Island (fig. 6). During the October 5

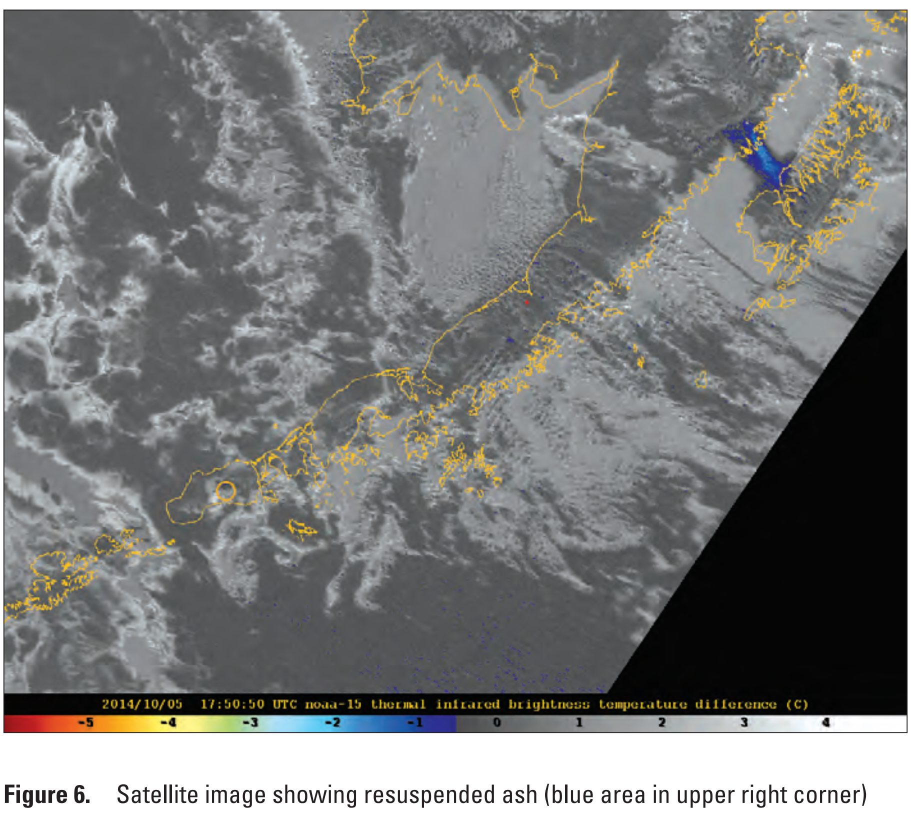

Figure 6. Satellite image showing resuspended ash (blue area in upper right corner) from the 1912 Novarupta eruption being carried southeast toward Kodiak Island, October 5, 2014. This plume of resuspended ash reached an estimated altitude of 1,200–1,800 m (4,000–6,000 ft) ASL. Satellite image from National Oceanic and Atmospheric Administration. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=80451.

event, a citizen of Kodiak reported ash to AVO using via AVO's "Is Ash Falling" system. Ash reached an altitude as high as 1,200–1,800 m (4,000–-6,000 ft) ASL during the October 5 event (fig. 6).

On October 14, strong winds in the Katmai area once again picked up loose 1912 volcanic ash and carried it east over Shelikof Strait and Kodiak Island. The National Weather Service estimated the top of the cloud at an altitude of 1,200 m (4,000 ft) ASL. The NWS issued a Special Weather Statement, and AVO received a report of hazy conditions and trace ashfall (less than 1/32 in. deep) at Karluk on the southwestern side of Kodiak Island through AVO's "Is Ash Falling" online ash reporting system. Federal Aviation Administration (FAA) Web camera images in Karluk also showed hazy conditions (fig. 7). AVO mentioned the resuspended ash event in the Friday, October 17, weekly update.

The last ash resuspension event of 2014 occurred on Thursday, October 23, when strong winds resuspended 1912 volcanic ash and carried it southeast over Shelikof Strait, Kodiak Island, and the Gulf of Alaska. The ash was detected in satellite imagery, and the NWS issued Special Weather Statements, SIGMETs, and a Volcanic Ash Advisory. AVO included the ash resuspension event in its Friday, October 24, weekly update.

The 1912 eruption of Novarupta-Katmai was the largest eruption of the 20th century, and produced about 17 km^3 (4 mi^3) of ash deposits and 11 km^3 (2.6 mi^3) of pyroclastic material that filled nearby valleys, creating what is known today as the Valley of Ten Thousand Smokes. Ash in this valley is as much as 200 m (660 ft) thick, and the valley remains almost entirely free of vegetation.

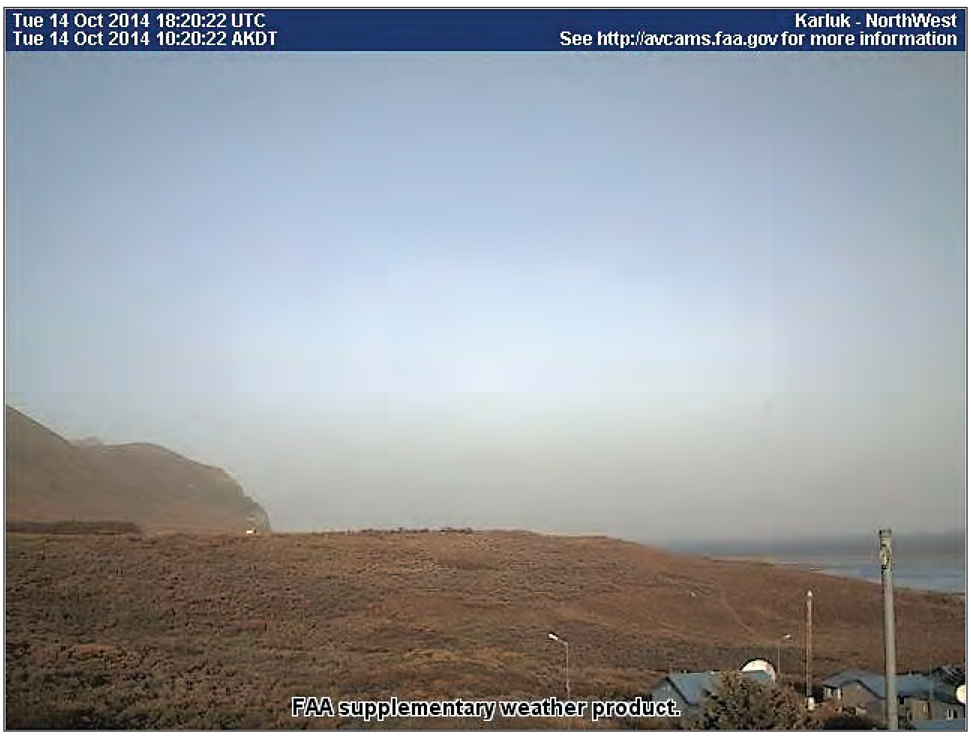

Figure 7. Web camera view showing hazy conditions created by resuspension of 1912 Novarupta ash, October 14, 2014. Image from Federal Aviation Administration Web camera NW Karluk. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=80461.

Mount Martin

GVP # 312140

58°10'N 155°21'W
1,860 m (6,102 ft)

Alaska Peninsula

EARTHQUAKE SWARM; VAPOR PLUMES

Mount Martin has no confirmed historical eruptions, but a very active fumarole field in a large, open crater at its summit has been the source of frequent robust steam plumes that are often called to AVO's attention. Throughout 2014, the Aviation Color Code and Volcano Alert Level for Martin remained **GREEN/NORMAL**.

Beginning on October 7, the AVO seismic network recorded an earthquake swarm centered roughly 15 km (9.3 mi) northwest of Mount Martin in an area where about 10 earthquakes per year are recorded. Twenty-six earthquakes were recorded on October 7, and, over the next 5 days, a total of 40 earthquakes were recorded. The largest earthquake in the swarm was a M1.8 on October 7. Seismicity in the Katmai region is dominated by earthquakes at volcanic centers; this swarm occurred in an established cluster of seismicity, closest to Mount Martin. The cluster of seismicity is dominated by shallow (less than 10 km [6.2 mi] deep) earthquakes with calculated magnitudes less than M2. No specific cause has been identified for the long-lived seismicity at this location.

On November 24, observers in King Salmon emailed AVO about robust steam plumes rising about 300 m (about 1,000 ft) above Mount Martin (fig. 8). Observers reported that the plumes continued until the evening of November 25, after which they were no longer visible from King Salmon. These fumarolic vapor plumes are common at Mount Martin (McGimsey and Neal, 1996; McGimsey and Wallace, 1999; Neal and others, 2005; McGimsey and others, 2007; Herrick and others, 2014).

Mount Martin is a stratovolcano in Katmai National Park and Preserve on the Alaska Peninsula, about 475 km (295 mi) southwest of Anchorage. Martin's summit cone sits at an elevation of roughly 1,850 m (6,102 ft) ASL. A summit crater about 300 m (about 1,000 ft) across contains an ephemeral, shallow lake and vigorous fumaroles that emit jets of sulfur-rich, volcanic gases. No historical eruptions of Mount Martin are known, but the fumarole field frequently produces towering vapor plumes as high as 1,000 m (3,300 ft) above its summit. A series of thick lava flows, the oldest of which were emplaced prior to about 6,000 years ago, extend north and northwest from the summit crater area (Fierstein and Hildreth, 2001).

Figure 8. Vigorous fumarolic plume from Mount Martin, as viewed from King Salmon looking southeast, November 24, 2014. Mount Martin has a long-lived, active fumarole field that often produces impressive steam plumes under optimal atmospheric conditions. Photograph by Robert Gary Hadfield, used with permission. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=68571.

Mount Chiginagak

GVP # 312110

57°08'N 156°59'W
2,135 m (7,005 ft)

Alaska Peninsula

INCREASED FUMAROLIC ACTIVITY

On September 30, 2014, AVO received an alert from the National Oceanic and Atmospheric Administration National Environmental Satellite, Data, and Information Service (NOAA-NESDIS) of elevated surface temperatures at Chiginagak volcano observed in MODIS and VIIRS satellite data (fig. 9). The thermal anomaly also was observed in AVHRR satellite data. Worldview data from July 31 and September 28 show no significant change in the summit crater; however, on September 29, AVO received a photograph of the northern flank of the Chiginagak volcano from a resident at lower Ugashik Lake, showing that the long-lived fumarole field on the northern flank had expanded several hundred meters downslope (fig. 10). After September 29, AVO received no new photographs or satellite observations indicating the presence of this expanded fumarole field, so it is uncertain how long this increase in heat flow persisted. This is the most extensive expansion of the fumarole field that has occurred in recent years, at least since the 2004–2011 field seasons, when repeated visits were made (see northern flank fumarole photographs, fig. 29, in Schaefer and others, 2013).

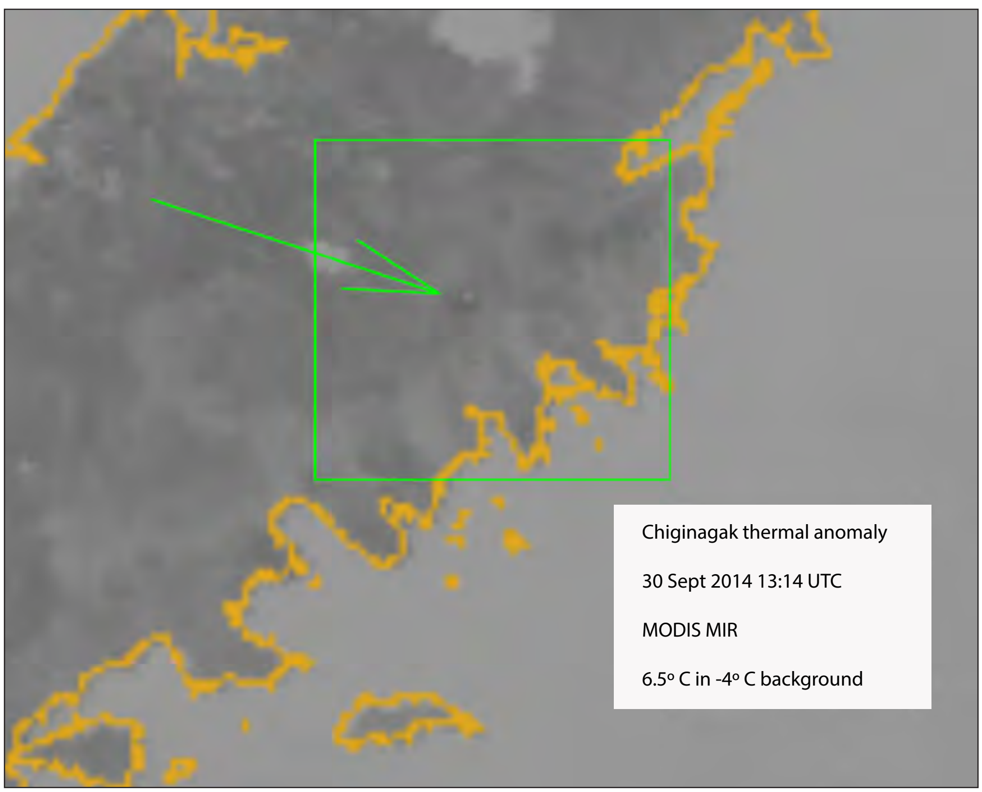

Figure 9. MODIS mid-infrared satellite image showing elevated surface temperature at Chiginagak volcano (lighter-colored pixels), September 30, 2014. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=80471.

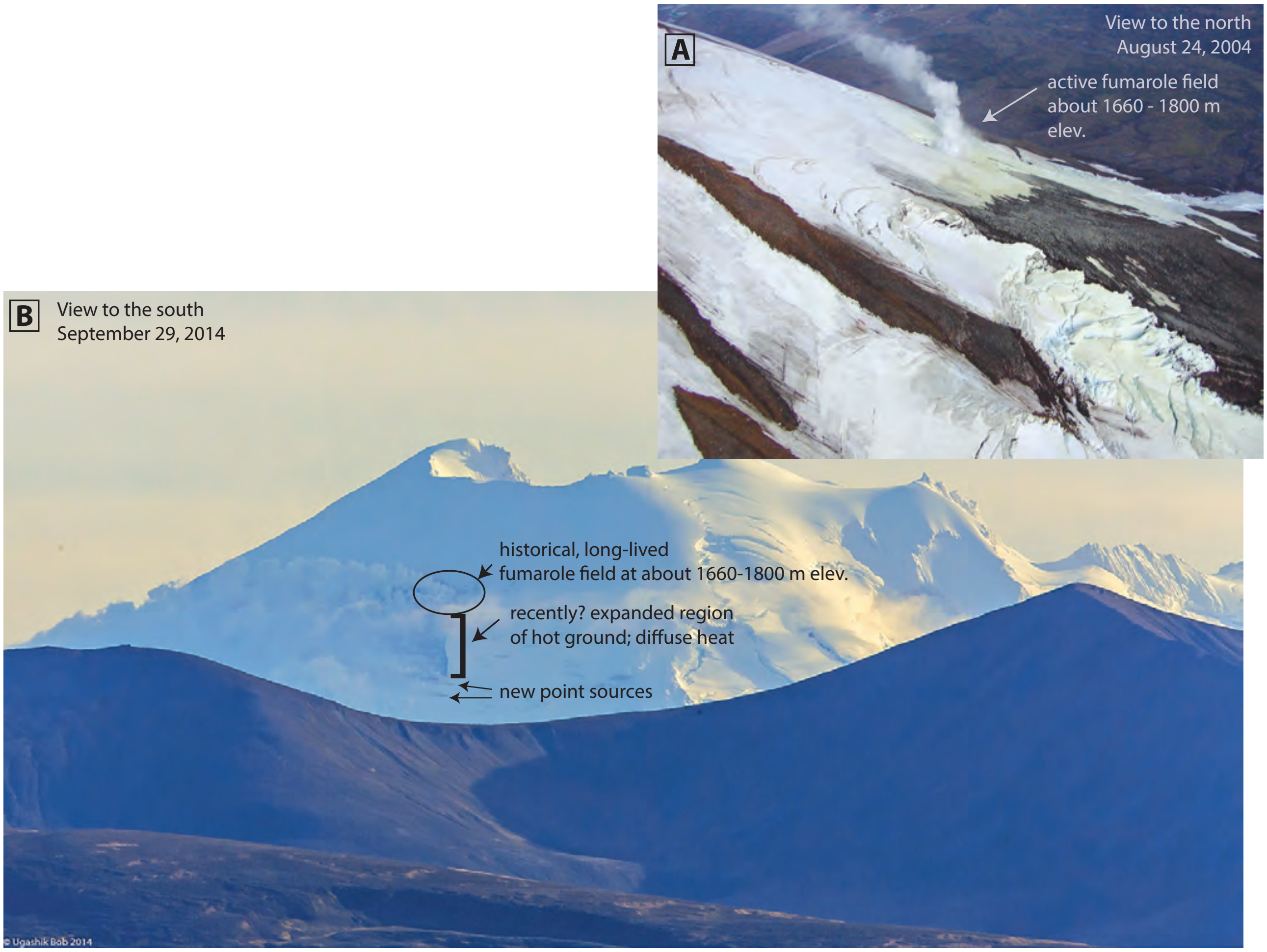

Figure 10. (A) View to the north showing the long-lived fumarole field on the northern flank of Chiginagak volcano, August 2004. The fumarole field is located between about 1,600 and 1,800 ft ASL. Photograph by Janet Schaefer, ADGGS/AVO, August 24, 2004. AVO database image URL, https://avo.alaska.edu/images/image.php?id=1081. (B) View to south showing same fumarole field with expanded region of warm ground and new point source fumaroles lower down the volcano flank, September 29, 2014. Photograph by Robert Dreeszen, used with permission. AVO database image URL, https://www.avo.alaska.edu/images/image.php?id=68051.

Chiginagak is a nearly symmetrical stratovolcano about 8 km (5 mi) in diameter located 175 km (110 mi) south of King Salmon on the Alaska Peninsula. Extensive glacial erosion on the southern flank has exposed highly altered interbedded lava flows and breccia, and evidence of an extensive hydrothermal system. The uppermost part of the cone, about 1,000 m (3,280 ft), is covered with perennial snow and ice, including the small ice-filled summit crater. A long-lived fumarole field high on the northern flank at an elevation of about 1,675 m (5,500 ft) ASL continuously emits steam and sulfur gases. Low on the northwestern flank, a cluster of thermal springs produces an estimated 6,100 L/min (1,611 gpm) of heated water with the warmest measured consistently at 66 °C (151 °F) (Motyka and others, 1981, 1993). Reports of historical eruptions at Chiginagak are few and uncertain (Miller and others, 1998). In 2005, a flux of heat to the summit area caused the summit snowcap to melt, forming an acid lake that was catastrophically released in early May 2005. This acid water and accompanying aerosol drainage caused significant damage to fish and vegetation in downstream drainages. A similar event may have occurred in the early 1970s according to third-person accounts from a cabin owner on Mother Goose Lake, who reported flooding from the volcano, discoloration of the lakeshore, vegetation damage, and interruption of the annual salmon run (Jon Kent, local lodge owner, oral commun., 2004). Other, older reports of activity at Chiginagak in 1852 and 1929 may be merely reporting the presence of the active fumaroles, which often produce visible steam plumes (McGimsey and others, 2007).

Aniakchak

GVP # 312090

56°54'N 158°13'W
1,341 m (4,400 ft)

Alaska Peninsula

FAILURE OF SEISMIC MONITORING NETWORK

In late 2013, because of reduced maintenance schedules, AVO's six-station seismic network at Aniakchak was reduced to one functioning station—ANNE. By mid-January 2014, ANNE also ceased functioning. Because AVO was unable to immediately repair the network, Aniakchak was formally removed from the list of seismically monitored volcanoes on January 24. AVO downgraded the Aviation Color Code and Volcano Alert Level to **UNASSIGNED**, where it remained through the rest of 2014.

Aniakchak is a circular caldera 10 km (6.2 mi) in diameter and as deep as about 1,000 m (3,280 ft) from the rim to the caldera floor. The caldera formed during a catastrophic eruption of some 75 km^3 (18 mi^3) of material about 3,400 years ago (Miller and Smith, 1987; Dreher and others, 2005; Bacon and others, 2014). Numerous lava domes, lava flows, and scoria cones occupy the interior of the caldera (Neal and others, 2001); the largest intracaldera cone is Vent Mountain, which is 2.5 km (1.5 mi) in diameter and rises 430 m (1,140 ft) above the surrounding caldera floor. The only historical eruption of Aniakchak, a powerful explosive event that spread ash over a large part of the eastern Alaska Peninsula, occurred in 1931 (Nicholson and others, 2011).

Mount Veniaminof

GVP # 312070

56°12'N 159°23'W
2,507 m (8,225 ft)

Alaska Peninsula

END OF ERUPTION

Mount Veniaminof volcano began an effusive eruption, punctuated by ash emissions and Strombolian explosions in early June 2013. The eruption continued over the next 5 months, producing ash emissions, constructing a new spatter cone nested within the summit crater of the main cone, and producing five lava flows that advanced down the flanks of the active cone and onto the surrounding ice, filling the caldera floor (Dixon and others, 2015). Seismicity began to decrease and the effusive eruptive activity subsided in mid-October. AVO downgraded the Aviation Color Code and Volcano Alert Level to YELLOW/ADVISORY on October 17, 2013, where it remained through July 2014, as the seismicity continued to steadily decrease (table 2; fig. 11). During this period, elevated surface temperatures, consistent with cooling lava flows, were observed in clear satellite images. Web camera images and aerial views on clear days typically revealed minor steam emissions from the summit of the intracaldera cone (fig. 12).

The volcano gradually returned to a state of rest, and by early July 2014, seismicity had returned to normal background levels (fig. 11). AVO downgraded the Aviation Color Code and Volcano Alert Level to GREEN/NORMAL on July 9, 2014. Minor steam emissions and cooling of the lava flows continued intermittently for the remainder of the year (figs. 13 and 14). Several episodes of low-frequency events and tremor bursts occurred over the last one-half of the year (for example, July 15, October 8, December 18) as reported by AVO seismologists; however, these events were not associated with eruptive activity and are interpreted as continued degassing of the magmatic system.

Mount Veniaminof, an ice-clad, andesite and dacite stratovolcano topped by an ice-filled caldera 10 km (about 6 mi) in diameter, is located 775 km (482 mi) southwest of Anchorage and 35 km (22 mi) north of Perryville (fig. 1) With a volume of about 350 km^3 (about 84 mi^3), Veniaminof is one of the largest and most active volcanoes of the Aleutian Arc (Miller and others, 1998; Bacon and others, 2007). Two Holocene caldera-forming eruptions are recorded in extensive pyroclastic-flow deposits around the volcano (Miller and Smith, 1987). Veniaminof has had at least 14 eruptions in the past 200 years, all from the approximately 300-m-high (about 984-ft-high) intracaldera cone, which also was the site of the 2013–14 eruption. The last significant magmatic eruption prior to 2013 occurred in 1993–95 (Neal and others, 1995; McGimsey and Neal, 1996; Neal and others, 1996). The 1993–95 eruption was characterized by intermittent, low-level emissions of steam and ash, and production of a small lava flow that melted a pit at the base of the cone in the caldera ice field.

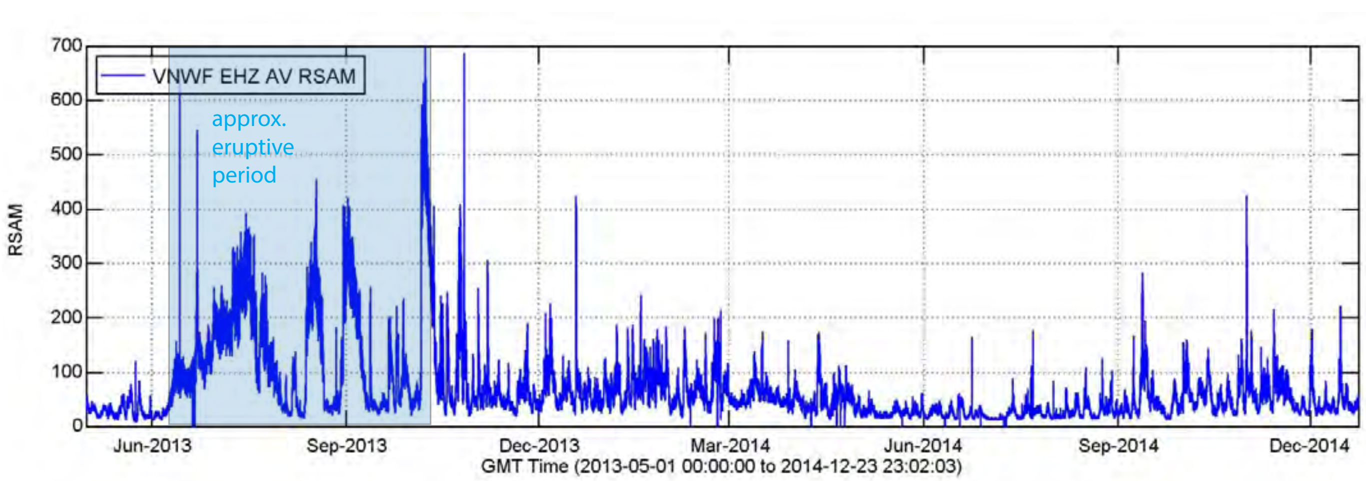

Figure 11. Real-time seismic amplitude measurement (RSAM) time series from Veniaminof seismic station VNWF (located on the lower southwestern flank of the caldera). Plot runs from June 2013 through December 2014 and shows the seismic energy release associated with 2013 eruption and the gradual decrease in seismicity beginning in late October 2013. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95311.

Figure 12. Aerial view from the southeast of steam rising from the intracaldera pyroclastic cone at Veniaminof, the source of the June 2013 eruption. Cooling lava flows are visible as snow-free ground below the steam plume. Photograph by Paul Horn, Alaska Department of Fish and Game, June 3, 2014. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=59341.

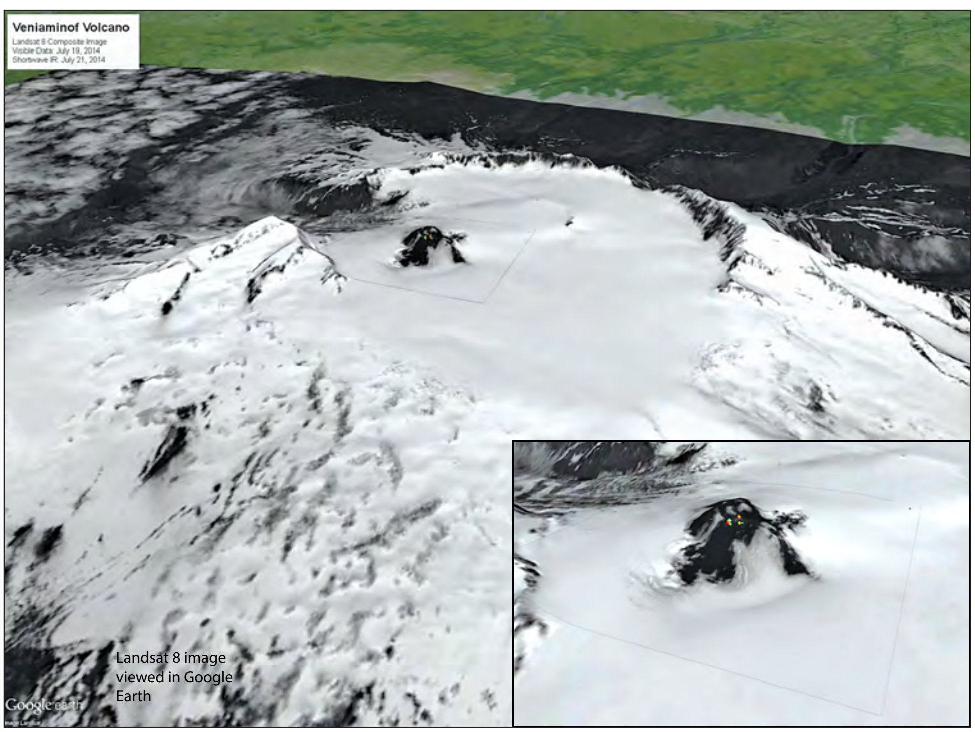

Figure 13. Composite Landsat 8 satellite image showing Veniaminof volcano and the intracaldera spatter cone, the source of the 2013 eruption. A zoomed-in view of the intracaldera cone is shown in the lower-right inset box. Brightly colored pixels indicate elevated surface temperatures associated with steam and gas vents in the summit crater. Image credit: Dave Schneider, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=108691.

Figure 14. Aerial view of Veniaminof volcano, intracaldera spatter cone, and cooling lava flows from the 2013 eruption. View is from the southwest and photograph was taken on August 3, 2014. By this time, Aviation Color Code and Volcano Alert Level had been downgraded from **YELLOW** to **GREEN**. Photograph by Cyrus Read, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66741.

Pavlof Volcano

GVP # 312030

55°25'N 161°54'W
2,518 m (8,261 ft)

Alaska Peninsula

INTERMITTENT LOW-LEVEL ERUPTION, STEAM AND ASH PLUMES

Pavlof Volcano (fig. 15) erupted twice in 2014—in May–June and again in November. These eruptions were characterized by periods of sustained lava fountaining, Strombolian explosions, and periods of continuous ash emission. Ash clouds reached heights of 7,600–11,600 m (25,000–38,000 ft) ASL during both eruptive periods, but ash fallout was limited to the proximal areas around the volcano (as much as about 11 km [7 mi] from the vent). Trace amounts of distal ash fallout were reported only in the community of Sand Point on June 3. The primary types of eruptive activity and significant observations are summarized in table 7. The disruption of air travel to Cold Bay and Dutch Harbor because of ash clouds from Pavlof during the 2014 eruption adversely affected the fishing industry for several days in June by preventing seafood workers from reaching job sites in Alaska.

The first eruptive episode at Pavlof in 2014 began at about 19:00 UTC (11 a.m. AKDT) on May 30, based retrospectively on a pulsating tremor-like signal in 1–5 Hz bandpass seismic data. The seismicity was visible across the Pavlof seismic network (fig. 15). By 07:22 UTC on May 31 (11:22 p.m. AKDT, May 30), satellite data showed a strong thermal signal, suggestive of lava at the surface. AVO upgraded the Aviation Color Code and Volcano Alert Level from **GREEN/NORMAL** to **ORANGE/WATCH** at 19:36 UTC (11:36 a.m. AKDT) on May 31. Subsequent analysis indicated that the opening phase of the eruption on May 31 was recorded on an infrasound network on Akutan Island about 278 km (173 mi) southwest of Pavlof. AVO received the first pilot reports of ash emission on June 1, indicating distinct ash clouds as high as about 3 km (2 mi) ASL, drifting north-northeast as much as 80 km (50 mi) beyond the summit of the volcano. Lahar (mud flow) signals were evident in seismic data from station PV6 by late in the day on June 1. These initial flows lasted for 15–30 minutes each, and were preceded by sustained low-level pulsatory tremor.

At about 01:30 UTC, June 3 (5:30 p.m. AKDT on June 2) , the amplitude of the seismic tremor increased significantly; Web camera, satellite views, and several pilot reports all indicated that a period of robust ash emission was underway. At this point, AVO upgraded the Volcano Alert Level and Aviation Color Code from **ORANGE/WATCH** to **RED/WARNING**, where it remained for about the next 24 hours. During this period, the volcano erupted almost continuously, and observers in Cold Bay reported incandescence at the summit, seismic stations recorded lahar signals, seismic tremor remained at high levels, and strong thermal signals were evident in satellite data. The highest ash plume generated during this period of heightened activity reached as high as 6,700 m (22,000 ft) ASL (based on pilot reports) and extended about 100 km (60 mi) to the southeast over Sand Point and Unga Island (fig. 15). Although there were no reports of ashfall in nearby communities on June 2–3, significant SO_2 emissions were detected in infrared atmospheric sounding interferometer (IASI) satellite data on June 3.

Beginning at about 06:30 UTC on June 3 (10:30 p.m. AKDT on June 2), the overall level of seismicity began to decrease slowly, and at 01:54 UTC on June 4 (5:54 p.m. AKDT on June 3), AVO downgraded the Aviation Color Code and Volcano Alert Level to **ORANGE/WATCH** in response to the decreased levels of seismicity. Although the tremor level was reduced, the overall level of seismic activity remained relatively steady throughout the day on June 3, and was associated with a mostly steam-and-gas plume, containing only minor amounts of ash reaching as high as 5,900 m (19,600 ft) ASL and drifting to the south. Trace amounts of fine ash were reported at the Sand Point airport on June 3–4, resulting in cancelation of flights to Sand Point on the morning of June 4. As many as five flights to Cold Bay and nine flights to Dutch Harbor also were canceled on June 3–4 because of the risk of encountering ash. Local commuter air service was suspended as well during this time, affecting air travel to King Cove and False Pass. Flight cancellations continued into June 5, disrupting flights to and from Dutch Harbor and Cold Bay.

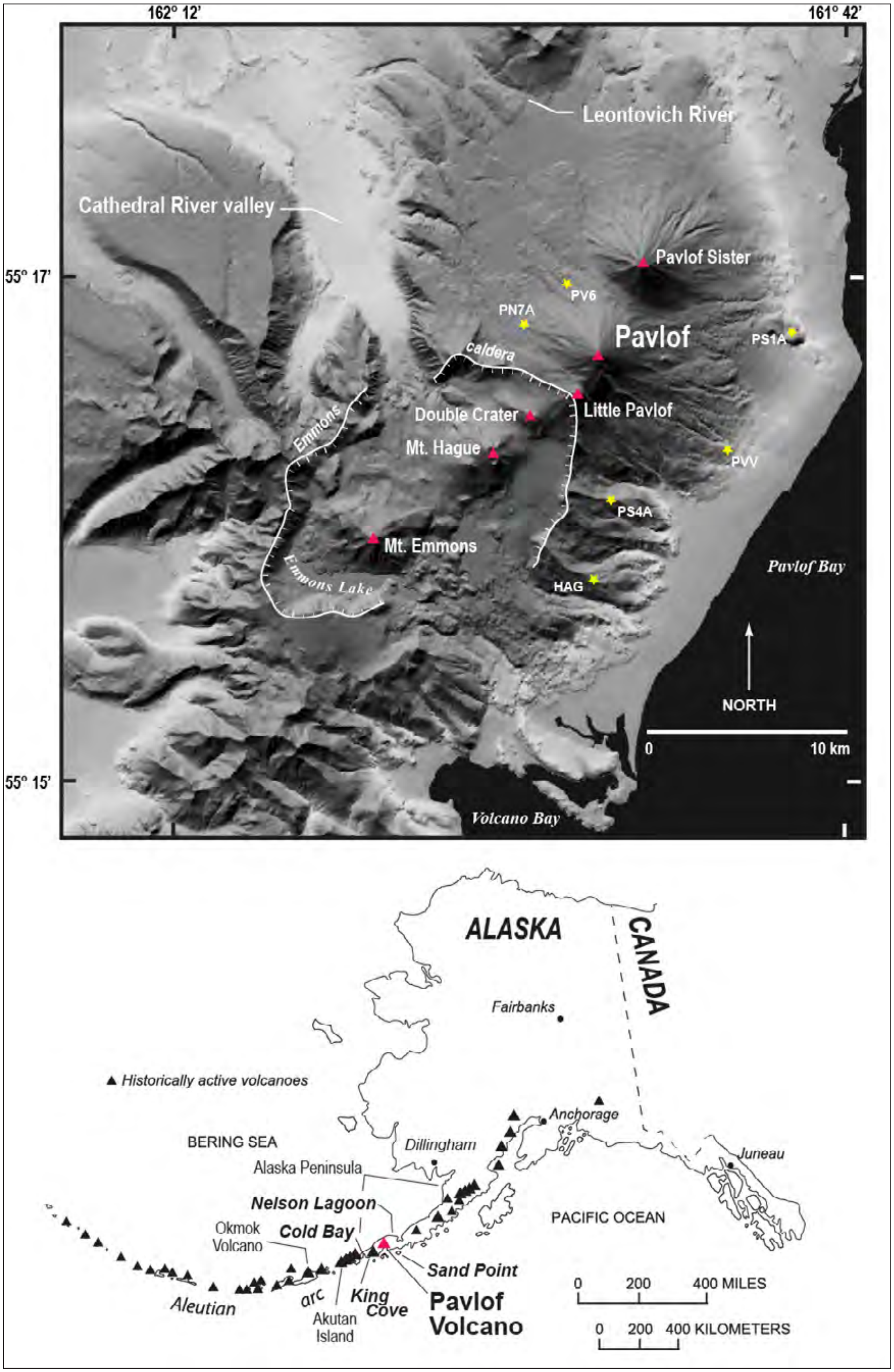

Figure 15. Shaded relief and location maps of Pavlof Volcano. Shaded relief map shows extent of Emmons Caldera and location of seismic network and place names referenced in report text. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95341.

Table 7. Summary of activity and observations at Pavlof Volcano in 2014.

[Data based on chronology compiled by Kristi Wallace, U.S. Geological Survey, Alaska Volcano Observatory (USGS/AVO); Alex Iezzi, University of Alaska Fairbanks Geophysical Institute and Alaska Volcano Observatory (UAFGI/AVO); and other AVO staff. **Abbreviations:** ASL, above sea level; UTC, Coordinated Universal Time. ft, foot; km, kilometer; mi, mile]

Date (UTC)	Color code/ Alert level	Activity	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
05-31-14	**GREEN/NORMAL**	Lava effusion, minor ash emission	Elevated surface temperatures observed in satellite data	Tremor detected
05-31-14	**ORANGE/WATCH**	Lava effusion, minor ash emission	Significantly elevated surface temperatures observed in satellite data	Atmospheric pressure waves detected by infrasound array on Akutan Island
06-01-14	**ORANGE/WATCH**	Lava effusion, minor ash emission	Significantly elevated surface temperatures observed in satellite data	Tremor detected
06-02-14	**ORANGE/WATCH**	Lava effusion, minor ash emission, and lahars	Mariner, ground observer and satellite observations of ash, lava, and flowage deposits	Lahar signals observed at station PV6
06-02-14	**RED/WARNING**	Significant ash emissions, explosions	Ash plume reaching 6.7 km (22,000 ft) ASL	Significant increase in tremor amplitude
06-03-14	**RED/WARNING**	Lava fountaining, ash emission, explosions, lahars	Ash plume reaching 4.9–5.5 km (16,000-18,000 ft) ASL	• Elevated levels of tremor • Lahar signals observed at station PV6
06-04-14	**ORANGE/WATCH**	Lava fountaining, ash emission, lahars	• Elevated surface temperatures observed in satellite data • SO_2 emissions detected	• Tremor amplitude declining • Lahar signals observed at station PV6
06-05-14	**ORANGE/WATCH**	Lava fountaining, ash emission	• Elevated surface temperatures observed in satellite data • SO_2 emissions detected • Lightning detected in vicinity of volcano	Seismicity remains steady and elevated
06-06-14	**ORANGE/WATCH**	Lava fountaining, ash emission	• Elevated surface temperatures observed in satellite data • SO_2 emissions detected	• Seismicity becomes less continuous, discrete events more apparent • Strombolian explosions decline
06-07-14	**ORANGE/WATCH**	Lava fountaining, ash emission	Elevated surface temperatures observed in satellite data	Discrete seismic events continue
06-08-14	**ORANGE/WATCH**	Lava fountaining, ash emission	• Elevated surface temperatures observed in satellite data • Lava flow, about 4 km (2.5 mi) long, observed on north flank in satellite data	Discrete seismic events continue
06-09-14	**ORANGE/WATCH**	Lava fountaining, ash emission	Elevated surface temperatures observed in satellite data	Discrete seismic events continue
06-25-14	**YELLOW/ADVISORY**	Intensity of lava fountaining and ash emission greatly diminished	Slightly elevated surface temperatures observed in satellite data	Level of seismic activity declining

Table 7. Summary of activity and observations at Pavlof Volcano in 2014.—Continued

Date (UTC)	Color code/ Alert level	Activity	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
07-30-14	GREEN/NORMAL	No activity occurring	Weakly elevated surface temperatures observed occasionally and associated with cooling deposits	Seismic activity at background levels
11-13-14	GREEN/NORMAL	Minor ash emission	Pilot report of ash emission to about 2.7 km (9,000 ft) ASL	Tremor levels increase
11-13-14	ORANGE/WATCH	Ash emissions, lava fountaining suspected	Elevated surface temperatures observed in satellite data	
11-15-14	RED/WARNING	Significant ash emissions, lava fountaining, lahars, lightning	• Pilot reports of ash plume reaching 9.1–11.6 km (30,000–38,000 ft) ASL • Rumbling sounds reported from Cold Bay, AK • Hot flowage deposits observed in satellite data • SO_2 emissions detected	• Seismic tremor markedly increased and continuous • Lahar signals observed at station PV6 Atmospheric pressure waves detected by infrasound array in Dillingham
11-16-14	RED/WARNING	Ash emissions, lava fountaining, lahars	• Pilot reports of ash plume reaching 11.3 km (37,000 ft) ASL • Elevated surface temperatures observed in satellite data	• Lahar signals observed at station PV6 • Seismic tremor levels begin to decline • Discrete seismic events apparent
11-16-14	ORANGE/WATCH	Ash emissions decline and end	• Elevated surface temperatures observed in satellite data	Seismic activity continues to decline
11-19-14	ORANGE/WATCH	Possible small lahars	• Elevated surface temperatures observed in satellite data, associated with cooling deposits Lava flow, about 6.7 km (4.2 mi)long, observed on north flank in satellite data	• Minor lahar signals observed at station PV6 • Declining seismicity
11-25-14	YELLOW/ADVISORY		• No evidence of eruptive activity in satellite data after 11-17-14 • Elevated surface temperatures observed in satellite data, associated with cooling deposits	
01-15-15	GREEN/NORMAL			Levels of seismic activity at background

The activity on June 2–3 was characterized by periods of vigorous lava fountaining (fig. 16) that resulted in the accumulation of lava spatter on the upper northern flank of the volcano. This accumulation resulted in the formation of a spatter-fed lava flow that eventually extended about 4.7 km (2.9 mi) downslope (fig. 17). At other times during the eruption, accumulations of spatter grew and built unstable piles of hot, fragmental material that occasionally collapsed and formed hot granular avalanches that flowed rapidly down the northern flank of the volcano for several kilometers. These hot granular rock avalanches swept across snow and ice, producing impressive steam plumes (fig. 18) and generating melt water that led to the formation of lahars in some of the main drainages on the northern flank of the volcano (fig. 17).

No ash or steam plumes were evident in satellite data after June 4, although seismic data recorded two explosions on the morning of June 5, and the World Wide Lightning Location Network (WWLLN) detected lightning near Pavlof from 10:16–10:59 UTC (2:16–2:59 a.m. AKDT) on June 5. Meteorological lightning is unusual in this part of Alaska, so the lightning likely was related to volcanic ash generated by the explosions. Emission of SO_2 also was detected in OMI satellite data on June 5, and the SO_2 plume extended from the volcano west about 100 km (60 mi).

On June 6, the level of seismic activity decreased appreciably, relative to the previous several days. From June 6–25, the level of unrest at the volcano continued to decrease further, and local observations of low-level lava fountaining were reported intermittently until about June 14. By June 25, satellite and Web camera data showed no evidence for lava fountaining or ash emissions. Only weakly elevated surface temperatures near the new lava flows on the northeastern flank were evident in satellite data. Consequently, AVO downgraded the Aviation Color Code and Volcano Alert Level to **YELLOW/ADVISORY** on June 25. By July 29 (AKDT) seismicity at Pavlof had returned to its normal background status and AVO downgraded the Aviation Color Code and Volcano Alert Level to **GREEN/NORMAL**.

Pavlof remained quiet and at background levels of seismicity until November 12, when seismic tremor increased sharply and increased surface temperatures were detected in satellite data, suggesting that lava had reached the surface. This was corroborated by reports of minor ash emissions and low-level lava fountaining from observers in Cold Bay. Observers also reported flows of rock debris and ash descending the northern flank of the volcano, and incandescence was observed in Web camera images. As a result of these observations, AVO upgraded the Aviation Color Code and Volcano Alert Level to **ORANGE/WATCH** on November 12.

Figure 16. Lava fountaining and incandescent mass flow at Pavlof Volcano during the early morning of June 2, 2014. View from Cold Bay, Alaska, about 58 km (36 mi) southwest of the volcano. Photograph by Rachel Kremer, used with permission. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=59151.

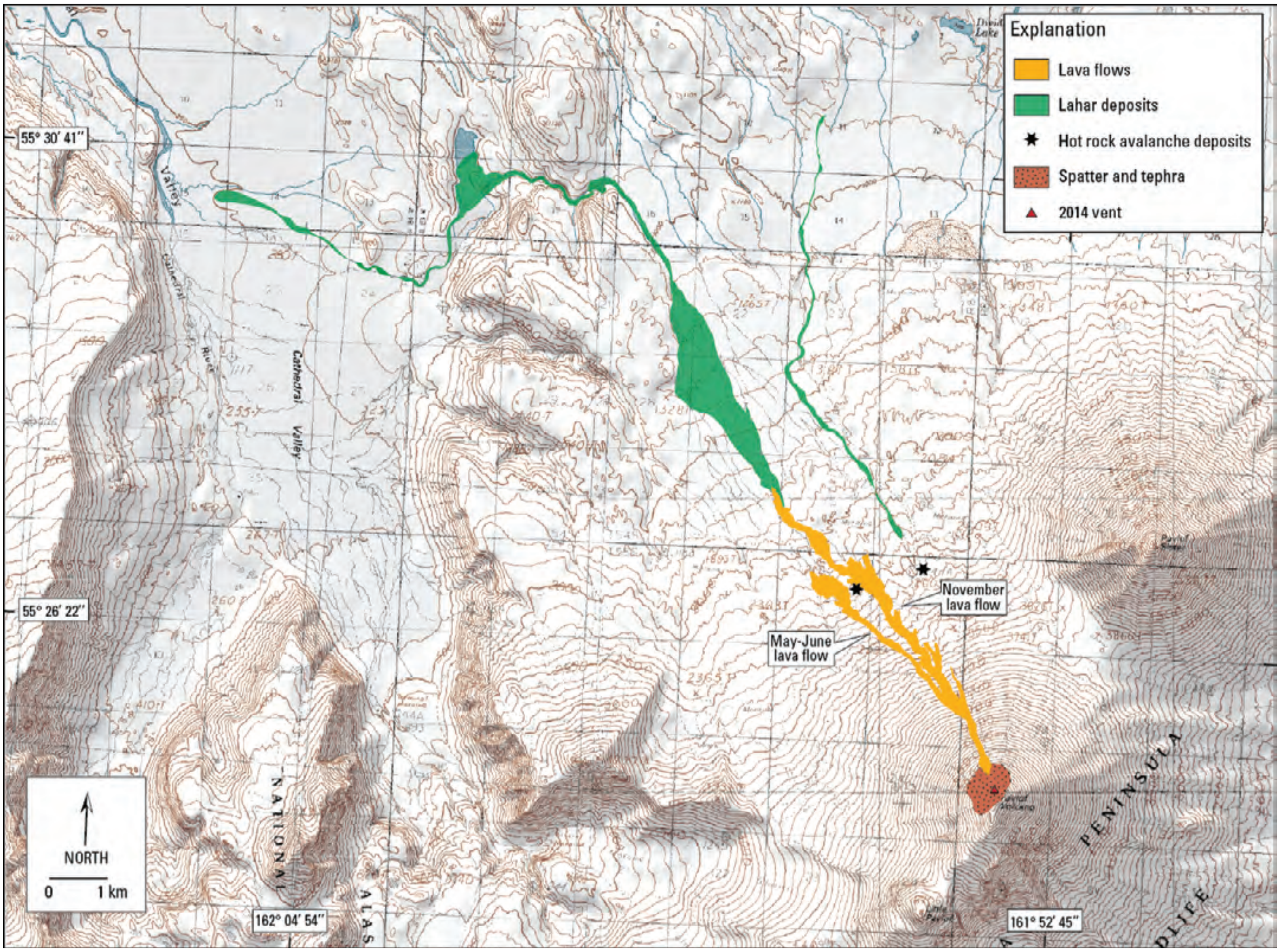

Figure 17. Map of principal eruptive products associated with eruptions of Pavlof Volcano, May–June and November 2014. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95361.

Figure 18. Pavlof Volcano as observed from Cold Bay, June 2, 2014 (time of day unknown). The light-colored steam plumes near the base and summit of the volcano (arrow) were produced by hot granular flows mixing with snow and ice on the northern flank of the volcano. The granular flows resulted from collapse of spatter accumulations emplaced near the summit vent. Photograph by Robert Stacy, used with permission. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95371.

After November 12, the level of seismic activity continued to increase gradually and the thermal signal at the summit became persistently visible in satellite data. On November 13, satellite data showed a 200-km-long (124-mi-long) ash plume extending northwest of the volcano. Pilot reports estimated the ash cloud top at about 2,400–2,700 m (about 7,900–8,900 ft) ASL. For the next 24 hours, all Pavlof seismic stations recorded nearly continuous seismic tremor, and satellite data showed strongly elevated surface temperatures, consistent with sustained lava fountaining. A narrow ash plume extending as high as 200 km (124 mi) from the volcano continued to be visible in satellite data, and information from passing pilots indicated that the ash plume eventually reached an altitude of about 4,800 m (15,700 ft) ASL. Minor SO_2 emissions were detected on November 14 in satellite data.

On November 15, the intensity of seismic tremor increased significantly over a 6-hour period and satellite data indicated that the ash cloud, visible for the previous several days, had expanded and reached an altitude of about 7,600 m (25,000 ft) ASL, and extended at least 200 km (124 mi) northwest of the volcano. In response to this increase in eruptive activity, AVO upgraded the Aviation Color Code and Volcano Alert Level to **RED/WARNING**. This plume eventually reached an altitude of at least 11,000 m (36,000 ft) ASL and extended about 385 km (240 mi) northwest of the volcano (fig. 19). Although the volcano was obscured by clouds, observers in Cold Bay reported rumbling and thunder-like sounds coming from the direction of Pavlof Volcano. Infrasonic tremor levels detected by the infrasound array in Dillingham increased steadily through the day on November 15 and were as high as, or higher than, infrasound levels recorded at any time during Pavlof's May–June 2014 or 2013 eruptions (David Fee, UAFGI/AVO, written commun., 2014). The SO_2 plume generated by this phase of the eruption extended west over the Bering Strait and into eastern Russia.

Seismicity at the volcano decreased significantly on November 16 and remained at low levels, and ash plumes were not observed in satellite data thereafter. In response to the decrease in seismicity and ash emission, AVO downgraded the Aviation Color Code and Volcano Alert Level to **ORANGE/WATCH** on November 16.

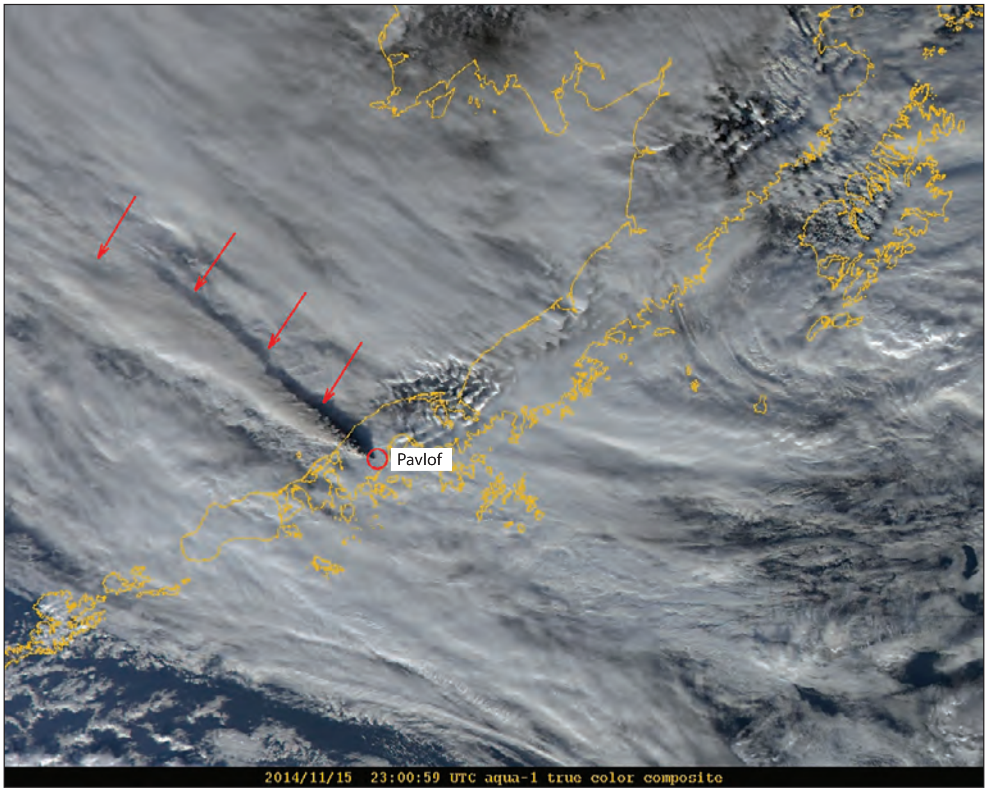

Figure 19. MODIS satellite image of ash plume from Pavlof Volcano (circled), observed in MODIS visible data, 23:00 UTC (2 p.m. AKST), November 15, 2014. Plume (see arrows) extended about 385 km (240 mi) northwest of the volcano. AVO database image URL: https://www.avo.alaska.edu/images/image.php?id=68471.

Satellite observations indicated that eruptive activity ceased by about November 17. The intensity of thermal signals decreased gradually and the levels of tremor fluctuated slightly, but the overall amplitude decreased steadily. Thermal signals were occasionally observed in satellite data through November 26, but were the result of the still hot lava and debris on the northern flank of the volcano. As a result of the diminished levels of unrest, AVO downgraded the Aviation Color Code and Volcano Alert Level to **YELLOW/ADVISORY** on November 26, UTC (November 25, AKST).

No further eruptive activity occurred at Pavlof Volcano in 2014, although unstable accumulations of cooling lava spatter occasionally collapsed, generating small ash emissions. The volcano gradually returned to normal background status, and on January 15, 2015, AVO downgraded the Aviation Color Code and Volcano Alert Level to **GREEN/NORMAL**.

Pavlof Volcano is a strikingly conical and symmetrical stratovolcano located on the southwestern end of the Alaska Peninsula, about 950 km (590 mi) southwest of Anchorage (fig. 15). The community of Cold Bay is located 60 km (37 mi) southwest of Pavlof. Based on the historical record, Pavlof is one of the most frequently active volcanoes in the Aleutian arc (Cameron, 2005). Eruptive activity typically is episodic Strombolian lava fountaining that persists for weeks or months. The last eruption of Pavlof prior to the 2014 eruptions was in 2013 (Dixon and others, 2015).

Shishaldin Volcano

GVP # 31360

54°45'N 163°58'W
2,857 m (9,373 ft)

Fox Islands, Aleutian Islands

INTERMITTENT LOW-LEVEL ERUPTION, STEAM AND ASH PLUMES

In early 2014, Shishaldin Volcano began a low-level eruption that produced intermittent lava within the crater, low-level steam plumes, and occasional dustings of ash and ballistics on its upper flanks. This activity persisted from January 30 through the remainder of 2014 (table 8, fig. 20). During the eruption, AVO monitored Shishaldin using the seismic array on Unimak Island, infrasound arrays at Akutan (135 km [84 mi] to the southwest) and Dillingham (582 km [362 mi] to the northeast), satellite imagery, a Web camera on adjacent Isanotski volcano looking northwest to Shishaldin, mariner observations, and pilot reports.

Web and satellite imagery of Shishaldin Volcano showed persistent, low-level steam plumes beginning on January 17, although such activity is not unusual at Shishaldin (fig. 21). On January 30, satellite data showed increased surface temperatures in the summit crater, and AVO upgraded the Aviation Color Code and Volcanic Alert Level to **YELLOW/ADVISORY** (table 2). Activity increased in early February, manifested by intermittent seismic tremor and airwave explosion signals recorded on distant infrasound instruments. On February 7, satellite data showed an ice-rich cloud at altitudes as high as 7,600 m (25,000 ft) ASL coming from Shishaldin, and AVO increased the daily watch schedule. Although this activity may have indicated a low-level eruption present in the summit crater, the eruption began no later than March 25, when satellite data indicated temperatures in the summit crater consistent with lava extrusion (fig. 22), and seismic and infrasound data recorded small explosions. On March 28, citing the inferred presence of lava in the summit crater, AVO upgraded the Aviation Color Code and Volcano Alert Level to **ORANGE/WATCH**. On March 30, 2014, a passing mariner photographed a darkened area at the crater rim, likely from a minor ash emission.

Throughout April, seismic and infrasound stations continued to record intermittent explosion signals, and steaming often was visible in clear Web camera views. On April 26, AVO received a PIREP of a steam plume at Shishaldin at an altitude as high as 3,800 m (12,500 ft) ASL. Probable ash darkened the upper flanks of the summit crater in Web camera images taken on May 5. On May 13, AVO again observed elevated surface temperatures at the crater consistent with lava extrusion in the crater (fig. 23, image from May 15). One month later on June 14, a NASA Earth Observing-1 Advanced Land Imager (EO-1 ALI) image showed a dusting of ash on the snow around the summit crater. A mariner report on June 28 also described a slight dusting of ash on the snow, and satellite data from July 1, 17, and 27 showed fresh deposits of ash on the flanks of the edifice, suggesting persistent, low-level eruptive activity within the summit crater, consistent with heightened seismicity and elevated surface temperatures (fig. 24).

AVO personnel conducting fieldwork photographed incandescence within the summit crater on August 10, 2014 (fig. 25). Activity at Shishaldin remained remarkably consistent throughout August and September—elevated surface temperatures observed in satellite imagery, evidence of explosions from infrasound and seismic data, intermittent tremor, and occasional steam plumes viewed by pilots or in the Web camera.

On October 1, satellite data again indicated temperatures within the summit crater consistent with extrusion of new lava. However, these elevated temperatures decreased by mid-October. Temperatures increased again on October 25, consistent with the reappearance of lava within the summit crater. This was accompanied by an increase in seismic tremor and explosions detected by infrasound. In response, AVO issued a Volcanic Activity Notice (VAN) on October 28 but the Aviation Color Code and Volcanic Alert Level remained at **ORANGE/WATCH**. After an apparent lull in eruptive activity between November 3 and November 20, the number and size of earthquake events at Shishaldin increased sharply, and AVO increased the watch schedule. At 10:00 UTC (1 a.m. AKST) on November 24, seismic activity again increased sharply, prompting AVO to issue another VAN at 10:49 UTC (1:49 a.m. AKST) warning of a greater risk of ash emission outside the crater. For the next 2 days, surface temperatures increased and there was an increase in the number of seismic events and explosions detected by infrasound. A robust steam plume was observed in satellite imagery, but no significant ash deposition occurred outside the crater. This slightly elevated activity lasted 2 days, after which the usual low-level eruptive activity continued at Shishaldin into 2015.

Shishaldin Volcano, located near the center of Unimak Island in the eastern Aleutian Islands, is a spectacular symmetric cone with a basal diameter of about 16 km (10 mi). A small summit crater typically emits a noticeable steam plume with occasional small amounts of ash. Shishaldin is one of the most active volcanoes in the Aleutian volcanic arc (Cameron, 2005).

Table 8. Summary of activity and observations at Shishaldin Volcano in 2014.

[Data based on chronology compiled by Kristi Wallace, U.S. Geological Survey, Alaska Volcano Observatory (USGS/AVO); and Alex Iezzi, University of Alaska Fairbanks Geophysical Institute and Alaska Volcano Observatory (UAFGI/AVO). **Abbreviations:** ASL, above sea level; PIREP, pilot weather report; VAN, Volcano Activity Notice. ft, foot; km, kilometer; m, meter: mi, mile]

Date/ Date range	Color code/ Alert level	Activity	Evidence, observations	AVO operational response
01-17-14 to 01-29-14	**GREEN/NORMAL**	Low-level steaming	Satellite data indicate persistent, low-level steam emissions from summit crater	
01-30-14 to 02-06-14	**YELLOW/ADVISORY**	Increased surface temperatures and steaming, airwave explosion signals	Satellite, Web camera, and seismic data, possible deformation signal	AVO issued a VAN, upgrading to **YELLOW/ADVISORY** on January 30, 2014
02-07-14 to 02-09-14	**YELLOW/ADVISORY**	Probable ice-rich volcanic cloud	Satellite data indicate ice-rich cloud, height about 7.6 km (25,000 ft) ASL	AVO increased watch schedule
02-10-14 to 02-13-14	**YELLOW/ADVISORY**	Elevated surface temperatures; faint intermittent tremor; steaming	Satellite, Web camera, and seismic data	
02-19-14 to 03-04-14	**YELLOW/ADVISORY**	Intermittent steaming and elevated surface temperature	Satellite data; clear Web camera views show steam from summit	AVO temporarily decreased watch schedule
03-04-14 to 03-25-14	**YELLOW/ADVISORY**	Steam plumes; elevated surface temperatures; airwave explosion signals; intermittent tremor	Satellite and Web camera data; seismic data; PIREP of small steam plume; possible tilt signal on March 18, 2014	
03-25-14 to 03-27-14	**YELLOW/ADVISORY**	Elevated surface temperatures consistent with new lava inside crater; airwave explosion signals; steaming	Satellite, Web camera, and seismic data	
03-28-14 to 03-29-14	**ORANGE/WATCH**	Elevated surface temperatures consistent with new lava inside crater; airwave explosion signals; steaming	Satellite, Web camera, and seismic data	AVO issued a VAN, upgrading to **ORANGE/WATCH** on March 28, 2014
03-30-14	**ORANGE/WATCH**	Probable minor ash emission	Darkening of crater rim photographed by mariner; photographs sent to AVO on April 1, 2014	
03-31-14 to 04-17-14	**ORANGE/WATCH**	Elevated surface temperatures; intermittent local earthquakes and airwaves; intermittent steam plumes	Satellite, Web camera, and seismic data	
04-17-14	**ORANGE/WATCH**	Increase in airwaves; steaming	Seismic and satellite data	

Table 8. Summary of activity and observations at Shishaldin Volcano in 2014.—Continued

Date/ Date range	Color code/ Alert level	Activity	Evidence, observations	AVO operational response
04-20-14 to 04-26-14	**ORANGE/WATCH**	Steaming; elevated surface temperatures; airwaves	Satellite, Web camera, and seismic data; PIREP of steam plume to 3.8 km (12,500 ft) ASL on April 26, 2014	
04-26-14 to 06-13-14	**ORANGE/WATCH**	Low-level eruptive activity; lava present in summit crater; explosion airwaves; intermittent tremor; intermittent steam plumes	Web camera showed ash on flanks on May 5; elevated surface temperatures in satellite data consistent with lava within the summit crater seen on May 13, 2014; Web camera steam plumes; seismic data; infrasound data from Akutan array	May 31, 2014, Pavlof eruption begins: AVO increases data checks for all volcanoes at elevated color codes
06-14-14	**ORANGE/WATCH**	Minor airborne ash; infrasound explosions	Minor airborne ash and dusting on snow seen in NASA EO-1 ALI image; infrasound signals	
06-15-14 to 07-04-2014	**ORANGE/WATCH**	Low-level eruptive activity; lava present in summit crater; intermittent small ash deposits; steam plume	Elevated surface temperatures in satellite data consistent with lava within the summit crater; Web camera steam plumes; June 27, 2014, PIREP of steam to 0.6 km (2,000 ft) above summit; mariner report of ash deposits on snow June 28, 2014; July 1, 2014, satellite data shows ash on southeastern side of edifice	
07-04-14 to 07-07-14	**ORANGE/WATCH**	Low-level eruptive activity; probable lava within summit crater; tremor signal	Elevated surface temperatures in satellite data; clear, non-consistent tremor in seismic data	
07-08-14 to 07-09-14	**ORANGE/WATCH**	Low-level eruptive activity; prominent steam plume; few local earthquakes	Elevated surface temperatures and steam plume in satellite data; seismic data	
07-09-14	**ORANGE/WATCH**	Increase in explosion airwaves	Seismic data; infrasound arrays at Dillingham and Akutan	
07-10-14 to 07-16-14	**ORANGE/WATCH**	Likely low-level eruptive activity; probable lava within summit crater; intermittent tremor; steaming	Elevated surface temperatures observed in satellite data; steaming in Web camera views; seismic data consistent with ongoing eruption in summit crater	
07-17-14 to 08-09-14	**ORANGE/WATCH**	Low-level eruptive activity; minor ash deposits; possible flowage features; steaming; intermittent tremor	Satellite data showing fresh deposits on flank July 17 and July 27, 2014; elevated surface temperatures in satellite data; Web camera and photographs of dark streaks on snow; steaming observed in Web camera; infrasonic tremor on August 8, 2014; intermittent tremor in seismic data	

Table 8. Summary of activity and observations at Shishaldin Volcano in 2014.—Continued

Date/ Date range	Color code/ Alert level	Activity	Evidence, observations	AVO operational response
08-10-14	**ORANGE/WATCH**	Visible incandescence in summit crater of Shishaldin	Photograph from AVO field personnel	
08-11-14 to 08-22-14	**ORANGE-WATCH**	Low-level eruptive activity; probable lava within summit crater; steaming	Elevated surface temperatures in satellite data; intermittent steaming (as high as 110 km [68 mi] from vent) in Web camera and satellite data; low seismicity	
08-23-14	**ORANGE/WATCH**	Steam and ash plume to 0.3 km (1,000 ft) above summit	PIREP	
08-24-14 to 09-22-14	**ORANGE/WATCH**	Likely low-level eruptive activity; steaming	Elevated surface temperatures in satellite imagery; intermittent steam plumes in Web camera; seismicity generally low, occasional airwaves	
09-23-14 to 09-30-14	**ORANGE/WATCH**	Likely low-level eruptive activity; steaming; infrasound explosions	Elevated surface temperatures in satellite imagery; intermittent steam plumes in Web camera and satellite imagery; infrasound tremor; seismicity generally low	
10-01-14 to 10-19-14	**ORANGE/WATCH**	Low-level eruptive activity; probable lava in summit crater; steaming	Strongly elevated surface temperatures consistent with lava extrusion in the summit crater seen in satellite imagery; intermittent infrasound tremor ground-coupled airwaves; seismicity slightly increased from previous period, including intermittent tremor and local earthquakes	
10-20-14 to 10-21-14	**ORANGE/WATCH**	Likely low-level eruptive activity continues; increased seismicity; explosion signals	Increase in low-frequency earthquakes and ground-coupled airwaves; elevated surface temperatures in satellite imagery	
10-22-14 to 10-24-14	**ORANGE/WATCH**	Likely low-level eruptive activity continues; low seismicity	Cloudy in satellite imagery and Web camera; slight decrease in seismicity	
10-25-14 to 11-03-14	**ORANGE/WATCH**	Increase in low-level eruptive activity; increased seismicity; small ash explosion	Increased tremor seen in seismic data; elevated surface temperatures consistent with lava in the crater seen in satellite imagery; explosions detected by infrasound; Web camera shows summit area darkened by ash and ballistics on October 26, 2014	AVO issued a VAN on October 28, 2014
11-04-14 to 11-19-14	**ORANGE/WATCH**	Likely low-level eruptive activity continues; seismicity decrease	Intermittent elevated surface temperatures seen in satellite data; mostly cloudy Web camera views; seismicity intermittent tremor	

Table 8. Summary of activity and observations at Shishaldin Volcano in 2014.—Continued

Date/ Date range	Color code/ Alert level	Activity	Evidence, observations	AVO operational response
11-20-14 to 11-23-14	**ORANGE/WATCH**	Likely low-level eruptive activity; seismicity increase	Number and size of earthquake events increased; elevated surface temperatures detected in satellite imagery	AVO increased watch schedule
11-24-14 to 11-26-14	**ORANGE/WATCH**	Probable increase in eruptive activity; lava in the summit crater; seismicity increase; infrasound explosions	Sharp increase in seismic activity at about 1:00 a.m. November 24, 2014; elevated surface temperatures consistent with lava in the summit crater seen in satellite imagery; explosions detected in infrasound data; steam plume evident in satellite imagery	AVO issued a VAN at 1:49 a.m. November 24, 2014
11-27-14 to 12-31-14	**ORANGE/WATCH**	Likely low-level eruptive activity continues; seismicity decrease	Elevated surface temperatures in satellite imagery; seismicity generally low; intermittent steaming seen in Web camera	AVO decreased watch schedule on December 10, 2014

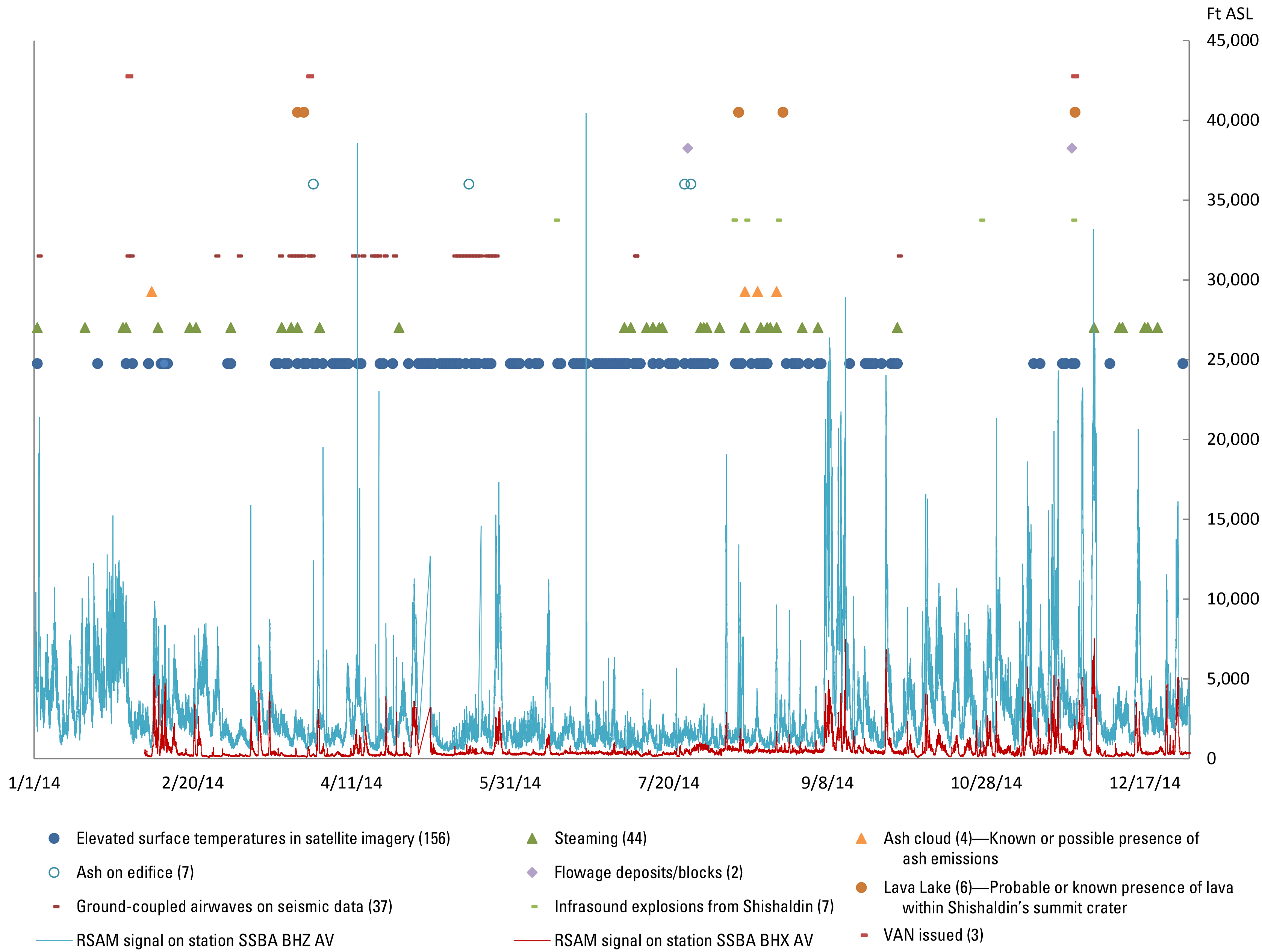

Figure 20. Visual timeline of activity and observations at Shishaldin Volcano in 2014. Number in parentheses indicates number of occurrences.

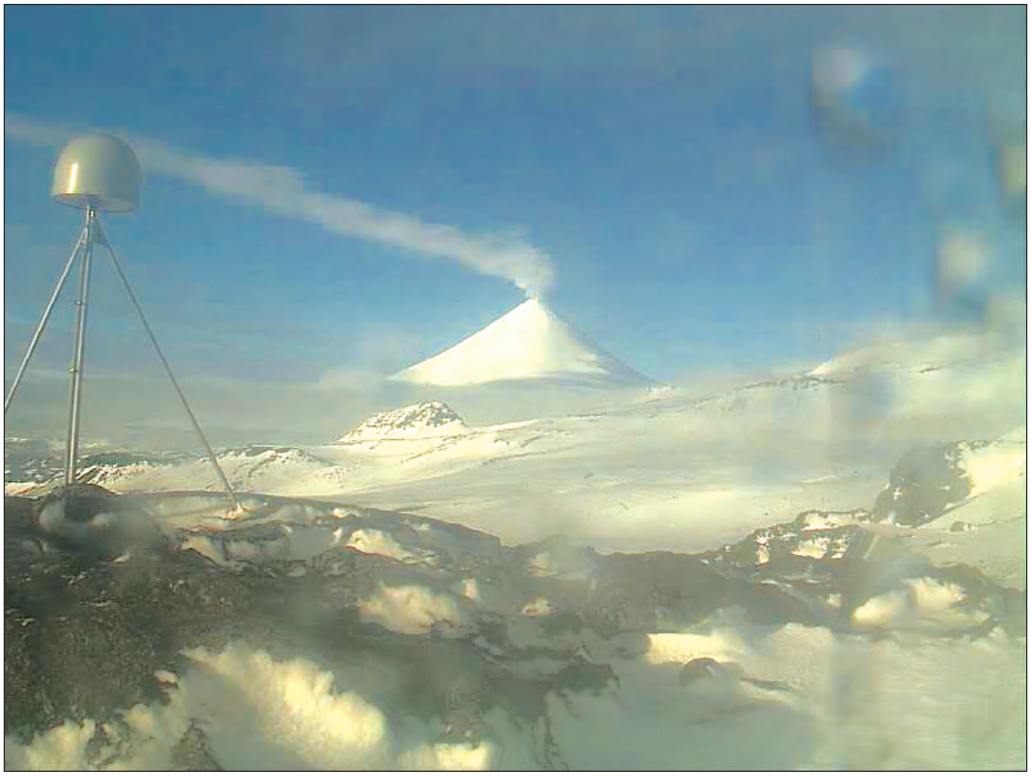

Figure 21. Web camera image showing a steam plume rising from the summit of Shishaldin Volcano, January 28, 2014. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=57701.

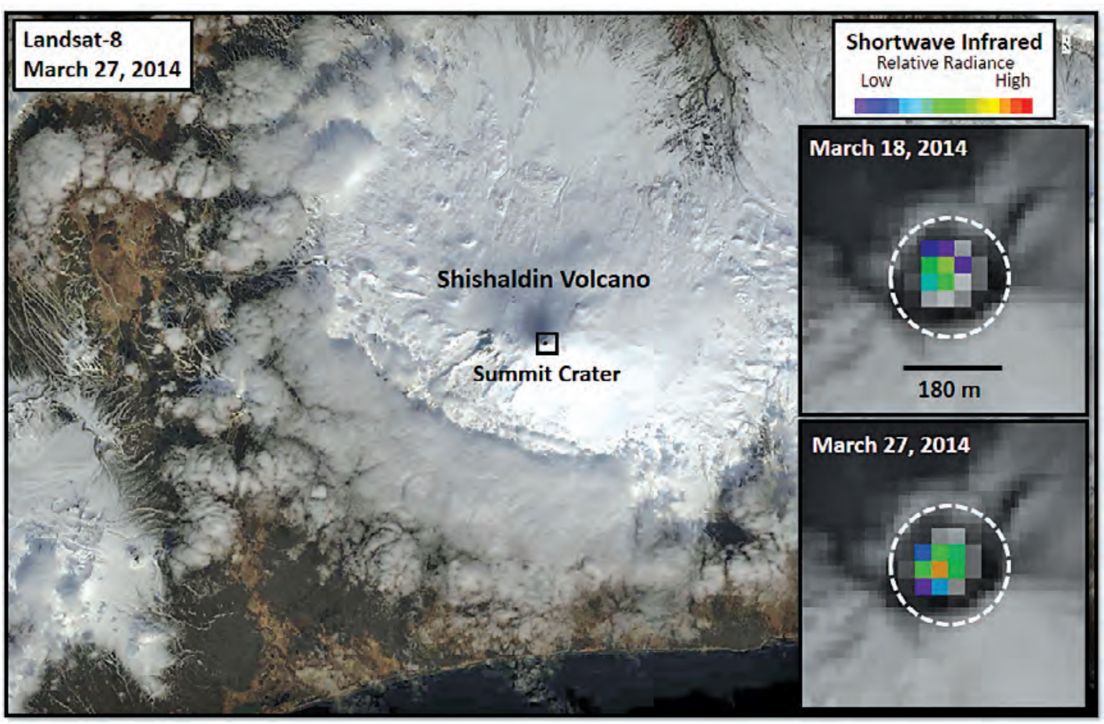

Figure 22. Landsat 8 image showing heat emission (radiance) from the lava in the summit crater of Shishaldin Volcano on March 18 and March 27, 2014. Image credit: Dave Schneider, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=57861.

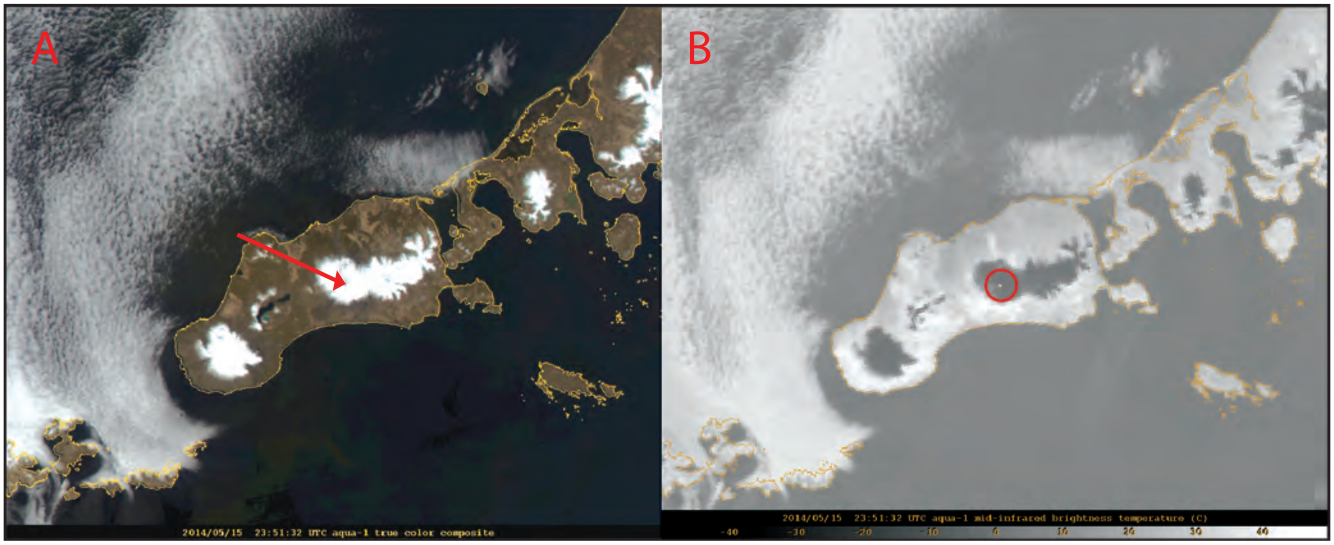

Figure 23. Coincident (A) true color and (B) mid-wavelength infrared images from NASA Aqua satellite (http://aqua.nasa.gov/) showing snow-covered volcanoes of Unimak Island, May 14, 2014. Arrow in (A) shows Shishaldin Volcano location, and circle in (B) encloses summit of Shishaldin Volcano with bright pixels indicating significant heat within the Shishaldin summit crater. This is interpreted as low-level eruptive activity with the presence of lava. Photograph by Christina Neal, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=58231.

Figure 24. View of Shishaldin from geophysical monitoring site BRPK southeast of the volcano, June 28, 2014. During a maintenance visit to Unimak Island in late June, good weather allowed the crew a good look at this active volcano. Small puff of steam is visible emerging from summit crater. Upper flanks of the volcano are darkened by ash erupted over the last several months during low-level lava fountaining and small explosions deep in the summit crater. Photograph by Dane Ketner, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66441.

Figure 25. Photograph of incandescence in the summit crater of Shishaldin, August 10, 2014. Photograph by Cyrus Read, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66771.

Akutan Volcano

GVP # 311320

54°25'N 165°58'W
1,303 m (4,275 ft)

Akutan Island, eastern Aleutian Islands

EARTHQUAKE SWARM; UPLIFT; PROBABLE MAGMATIC INTRUSION

A series of 34 earthquakes occurred on Akutan volcano on July 15, 2014. Nine of the earthquakes had a magnitude between 1 and 2; the rest were smaller. Following the earthquake swarm, AVO re-analyzed GPS data and concluded that Akutan experienced about 1 cm (0.4 in.) uplift around the time of the seismic swarm. The GPS data clearly show a volcanic inflation signal (outward and upward) with a start date at the beginning of 2014, most likely indicating intrusion of magma (Jeff Freymueller, UAFGI/AVO, written commun., 2014) (fig. 26). A second earthquake swarm of 24 earthquakes occurred 5 months later on December 7, including a M2.5 earthquake, 2–3 km (1.2–1.9 mi) south of Akutan. Tectonic tremor was noted throughout 2014, and is typical for the Akutan seismograph network.

Akutan is one of the most active volcanoes of the Aleutian arc, having erupted at least 31 times since 1790, most recently in 1992 (McGimsey and others, 1995). Occupying the western half of Akutan Island, the volcano is a symmetrical stratocone with a 2-km-diameter (1.2-mi-diameter) circular summit caldera. The caldera is breached to the northwest, and an active intracaldera cinder cone about 200 m (656 ft) high has been the site of all historical eruptive activity (Richter and others, 1998; Waythomas and others, 1998). The City of Akutan is 12 km (8 mi) east of the caldera rim, and one of the largest seafood-processing plants in the region (Trident) is located 1 km (0.6 mi) west of the city. In March 1996, two strong swarms of earthquakes occurred on the island, causing minor damage and prompting some residents and seafood-processing plant workers to leave the island (Lu and others, 2000). A permanent seismic network was installed in summer 1996.

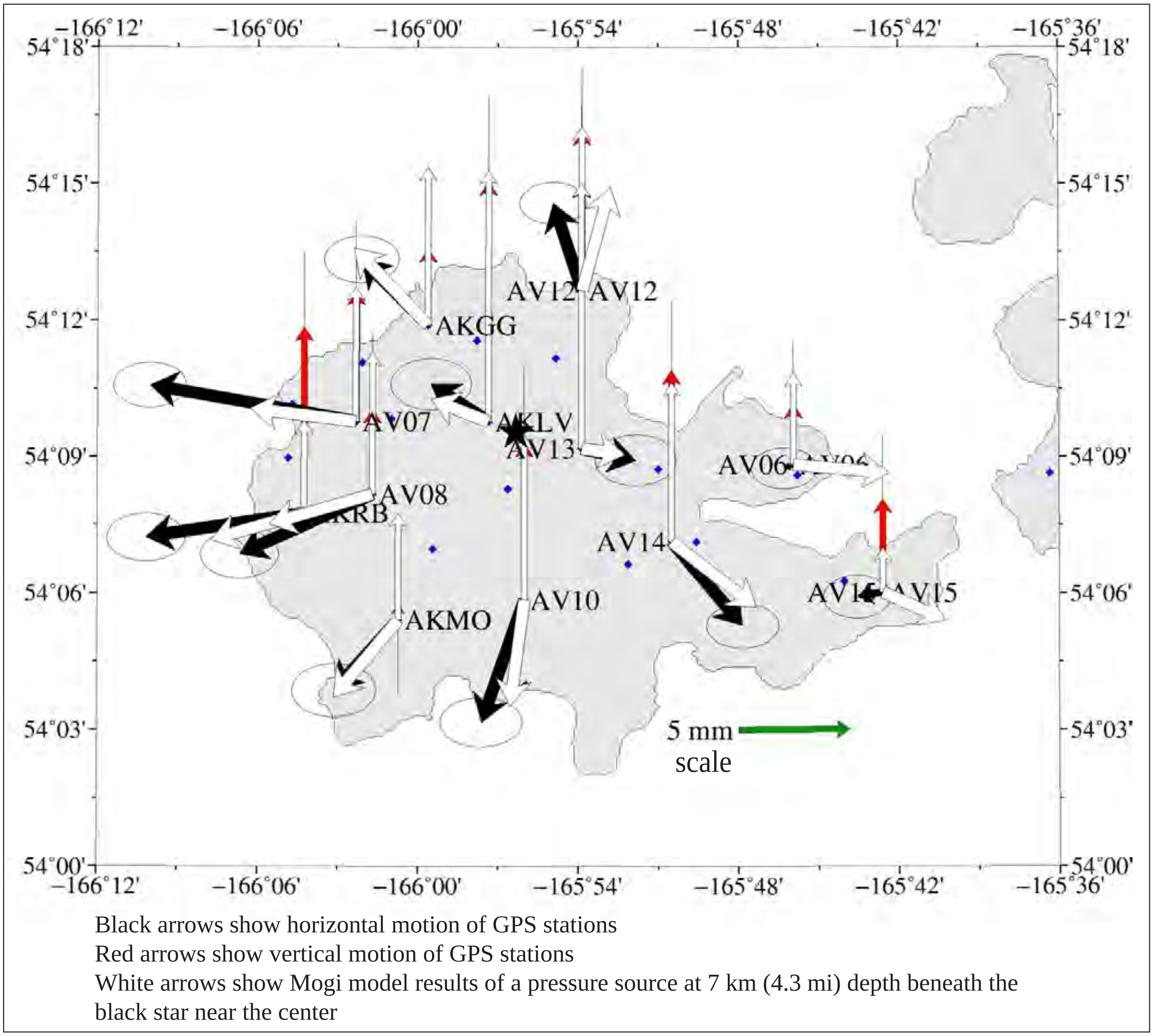

Figure 26. Map of Akutan Island showing Akutan 2014 Global Positioning System (GPS) observations compared to a Mogi model. From Jeff Freymueller, UAFGI/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=80811.

Okmok Volcano

GVP # 311290

53°25'N 168°08'W
1,073 m (3,520 ft)

Fox Islands, Aleutian Islands

RAPID INFLATION OF THE CALDERA

Okmok volcano continued to inflate during 2014—a general trend that started no more than 3 weeks after the volcano's 2008 eruption (Freymueller and Kaufman, 2010). More specifically, analyses of GPS and InSAR data from 2008 to present (2016) show evidence for two major pulses of post-eruptive inflation (Qu and others, 2015). Inflation of the volcano began at a rapid rate immediately after eruption and slowed with time, largely ceasing by mid-2013. A new pulse of rapid inflation began at that time, its rate slowly decreasing over time. Inflation continued through 2014, although at a much slower rate.

Okmok volcano is a 10-km-wide (6.2-mi-wide) caldera that occupies most of the eastern end of Umnak Island, located 120 km (75 mi) southwest of the important fishing and transportation hub of Unalaska/Dutch Harbor in the eastern Aleutian Islands. The volcano, built on a base of Tertiary volcanic rocks, consists of three rock series—(1) older flows and pyroclastic beds of a pre-caldera shield complex, (2) pyroclastic deposits of two major caldera-forming eruptions, and (3) a post-caldera field of small cones and lava flows that includes historically active vents in the caldera (Byers, 1959; Larsen and others, 2007). Okmok has had several eruptions in historical time, typically consisting of ash emissions occasionally reaching altitudes higher than 9,000 m (30,000 ft) ASL, but generally much lower; lava flows were emplaced on the caldera floor in 1945, 1958, and 1997 (Begét and others, 2005). The most recent eruption was a dramatic phreatomagmatic eruption over a 5-week period during summer 2008 (Neal and others, 2011). Thermal springs and fumaroles occur in the Okmok caldera and at Hot Springs Cove, 20 km (12 mi) to the southwest.

Mount Recheshnoi

GVP # 311280

53°09'N 168°32'W
1,984 m (6,509 ft)

Umnak Island, Fox Islands, Aleutian Islands

EARTHQUAKE SWARM

The AVO located more than 400 earthquakes in 2014 at Geyser Bight, an active geothermal area in the central part of Umnak Island, about 8 km (5 mi) km north-northeast of Mount Recheshnoi (fig. 27). More than 80 percent of these earthquakes were shallower than 4 km (2.5 mi); 16 events exceeded magnitude M2.0, and the two largest were M3.0 and M3.1. The Okmok seismic network was completed in 2003. Since then, three clusters of activity near Recheshnoi have become apparent—one cluster at the geothermal area of Geyser Bight (Nye and others, 1992; Motyka and others, 1993), a second cluster at Mount Recheshnoi, and a third cluster between the other two. Notable increases in seismicity occurred in this area in 2003, and another increase began in 2013 and persisted into 2014 (Dixon and others, 2015).

Mount Recheshnoi is a heavily glaciated Holocene-aged volcano located on the southern half of Umnak Island. A small isthmus connects the southern volcanoes of Umnak Island (Recheshnoi and the farther south Vsevidof) with Okmok volcano, which occupies the northern half of Umnak Island. Three Holocene andesite flows are found on its eastern and western flanks, the youngest of which is around 3,000 years old (Black, 1975; Nye and others, 1992; Motyka and others, 1993). Recheshnoi also hosts one of only three known occurrences of high-silica rhyolite (dated to 0.135 million years ago) in the Aleutian arc west of Novarupta (Nye and others, 1992; Motyka and others, 1993). A large zone of six hot thermal springs and small geysers, referred to as Geyser Bight, is dispersed over an area of 4 km^2 (1.5 mi^2). This geothermal area is one of the largest and hottest in Alaska (Nye and others, 1992).

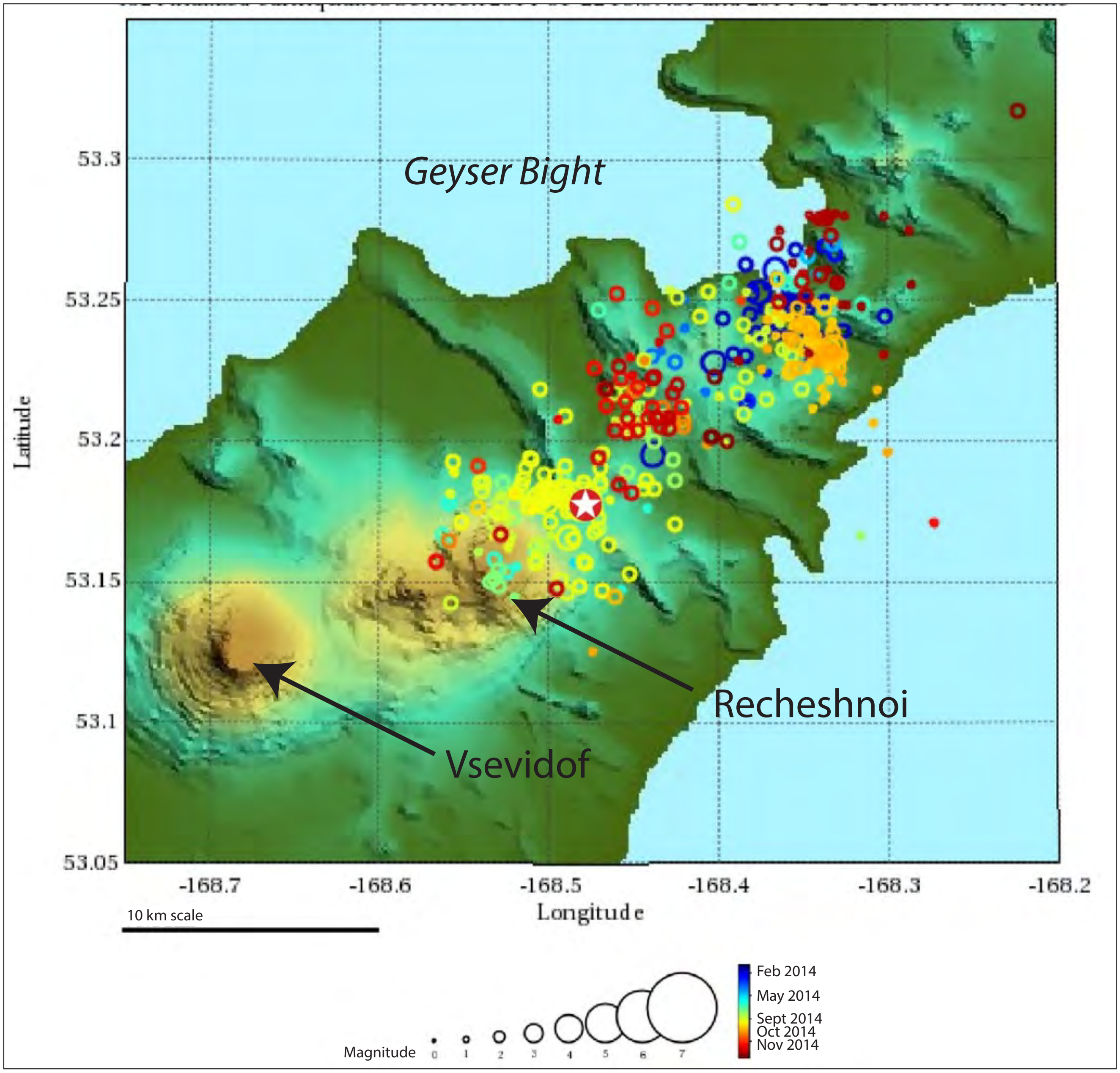

Figure 27. Map of central part of Umnak Island, showing Mount Recheshnoi, nearby geographic features, and earthquake locations and magnitudes in 2014. Total of 401 earthquakes were located at Geyser Bight in 2014. Largest earthquake had magnitude of 3.1 (shown by star), occurring on the eastern flank of Recheshnoi in a swarm of activity in September 2014. Two identified swarms occurred in the hot springs area in October and late November. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95381.

Mount Cleveland

GVP # 311240

52°49'N 169°57'W
1,730 m (5,676 ft)

Chuginadak Island , Fox Islands, Aleutian Islands

EXPLOSIONS AND SMALL ASH CLOUDS, ROCKFALLS, STEAM AND GAS PLUMES, LAVE EXTRUSION IN SUMMIT CRATER

Mount Cleveland continued intermittent eruptive activity throughout 2014, albeit at a lower rate compared to previous years. A flurry of explosions in late December 2013 (Dixon and others, 2015) and early January 2014 prompted a brief upgrade of the Aviation Color Code and Volcano Alert Level to **ORANGE/WATCH** through January 10. For the remainder of 2014, the Aviation Color Code and Volcano Alert Level were **YELLOW/ADVISORY**. Notably, AVO installed two seismic stations, an infrasound network, and a Web camera on Chuginadak Island, starting the first-ever real-time monitoring of this active volcano (figs. 28 and 29). Fieldwork associated with this installation, done in cooperation with a National Science Foundation-funded project, meant that for several weeks in late July and early August, observers in the field collected first-hand observations of the low-level unrest at Cleveland.

Activity and observations at Cleveland in 2014 are summarized in tables 9 and 10.

Before seismometers and a Web camera became operational in August 2014, the primary means of monitoring and detecting activity at Cleveland were satellite and distal infrasound data. AVHRR and MODIS satellite imagery, augmented by newly available Landsat 8 and other less-frequent, high-resolution views, detected elevated surface temperatures in the summit region on many occasions when weather conditions allowed clear views of the summit.

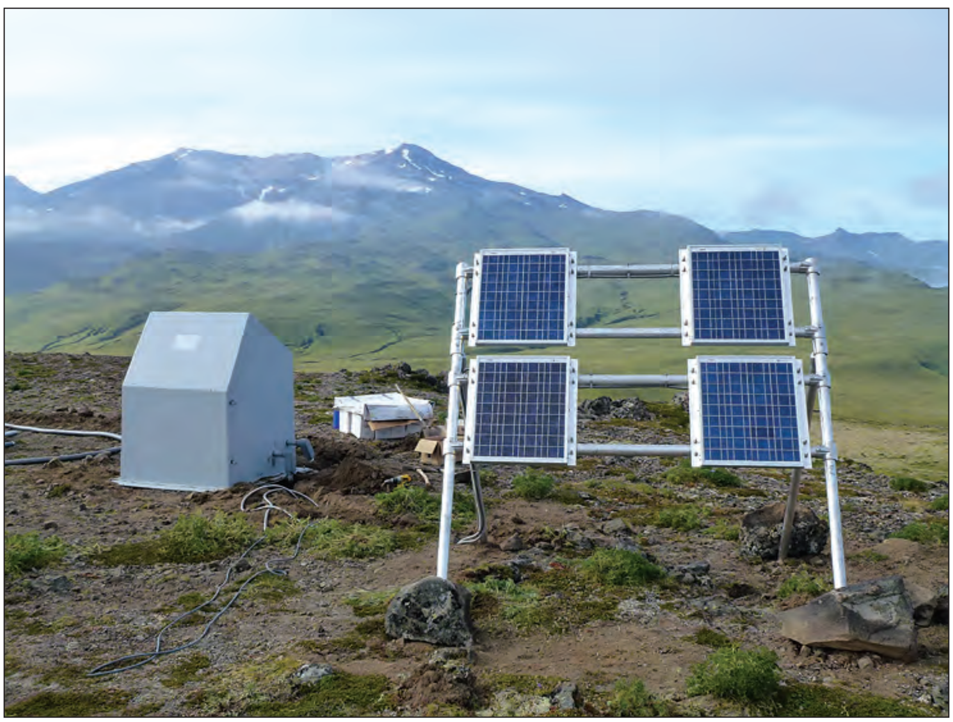

Figure 28. Photograph of AVO monitoring station CLCO, August 1, 2014. Gray hut contains batteries and electronics. The solar panel “swingset” in the foreground also contributes power to the monitoring station. Photograph by John Lyons, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=68991.

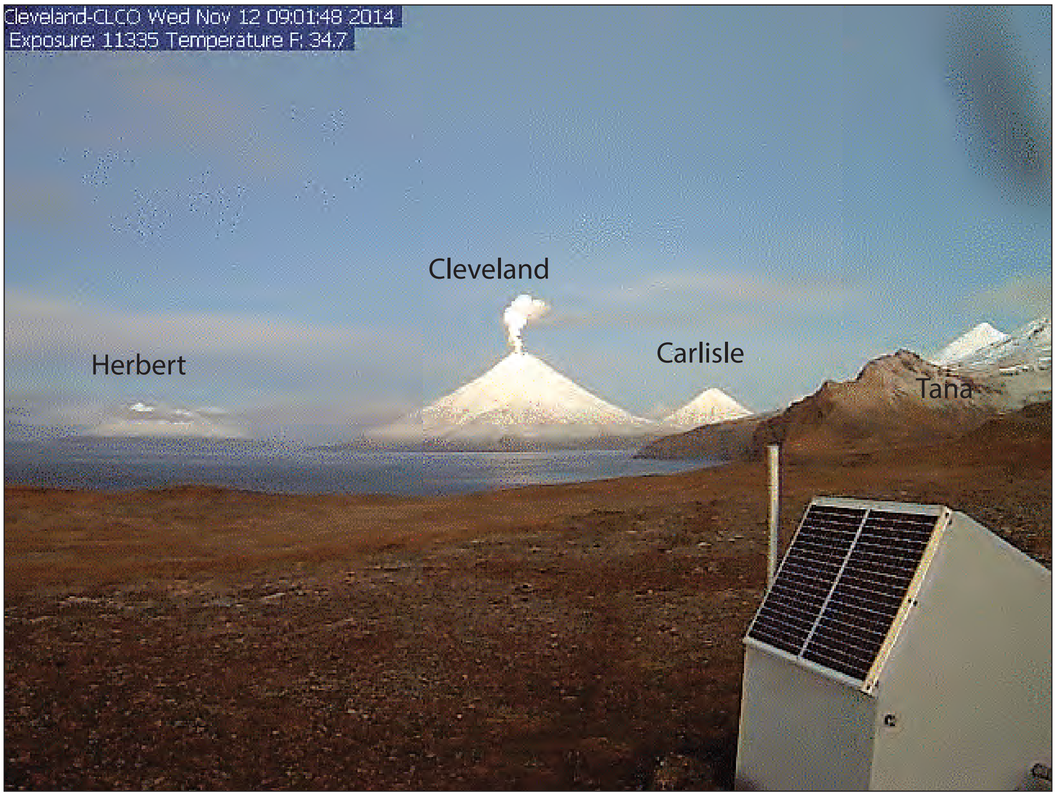

Figure 29. Web camera image (left to right) of Herbert, Cleveland (steaming), Carlisle, and Tana volcanoes from monitoring station CLCO, November 12, 2014. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=80821.

Typically, the area of elevated temperatures was confined to the summit crater and rim. Weak but distinct plumes of steam and volcanic gas also were noted occasionally in satellite imagery, by field observers during summer (fig. 30), and frequently in Web camera views. These plumes extended at most a few tens of kilometers downwind before dissipating. The presence of volcanic gas is inferred based on plume color, native sulfur deposition in the summit crater (fig. 31), and field party reports of occasional sulfur odor. No quantitative measurements of volcanic gas from Cleveland were made during the 2014 field season.

Only five, brief explosive events were detected with confidence in 2014 by a combination of infrasound and analysis of ground-coupled airwaves on seismic networks in the Aleutians, bringing to 36 the number of discrete explosions at Cleveland since infrasound analysis began in late 2011 (table 10; De Angelis and others, 2012; Matt Haney, USGS/AVO, written commun., 2014). These explosions occurred in early January, late February, and early June, and on November 6, and produced short-lived clouds of ash and gas tracked by satellite imagery as far as 75 km (46 mi) downwind. These ash clouds were likely below an altitude of about 4,500 m (15,000 ft) ASL, although the ash cloud from an explosion on February 25 briefly may have reached an altitude of 8,200 m (27,000 ft) ASL based on Defense Meteorological Satellite Program satellite image analysis (Dave Schneider, USGS/AVO, written commun., February 25, 2014). Lightning strikes related to the February 25 explosions were recorded on the WWLLN (Dave Schneider, USGS/AVO, written commun., 2014).

On March 6, residents of Nikolski village on the southwestern end of Umnak Island 73 km (45 mi) northeast of Cleveland reported dark ash rising from Cleveland at about 03:30–04:00 UTC on March 7 (6:30 or 7 p.m. AKST, March 6). In later discussions by telephone, residents further reported that, over a period of about 40 minutes, before the volcano became obscured by weather, alternating clouds of white steam and dark ash rose above the summit; the dark ash clouds rose about twice as high as white clouds but both dissipated quickly. Similar activity had been noted several months prior, so it is likely that other small episodes of ash emission have gone undocumented in the AVO database of eruptive activity from Cleveland during cloudy conditions when visual observations could not be made. The activity on March 6 was too ephemeral or small to be noted even in clear satellite views.

Table 9. Summary of activity and observations at Cleveland volcano in 2014.

[Original chronologic compilation by Kristi Wallace, K. Benson, Alex Iezzi, and Christina Neal, USGS/AVO. **Note:** An important reporting change occurred in May 2013 when AVO analysts stopped reporting the number of pixels with elevated temperatures seen in satellite images. After May 2013, the presence of elevated surface temperatures is noted with the phrase "Elevated temperatures." Absence of elevated temperature entries may simply mean clouds obscure the ground. **Abbreviations:** AKST, Alaska Standard Time; ASL, above sea level; AVHRR, Advanced Very High Resolution Radiometer; MODIS, Moderate Resolution Imaging Spectroradiometer; SWIR, Short Wave Infrared; UTC, Coordinated Universal Time. °C, degrees Celsius; ft, foot; km, kilometer; m, meter; mi, mile]

Date	Color code/ Alert level	Activity	Elevated surface temperatures, satellite sensor	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
1/1/2014	**YELLOW/ADVISORY**				
1/2/2014	**ORANGE/WATCH**	Two explosions, ash clouds to NNE and W about 75 km. Below 4.6 km (15,000 ft) ASL		Discrete small ash cloud observed 0400 UTC 1/2/2014 in AVHRR Brightness Temperature Difference image	Single explosion detected at 03:34
1/10/2014	**YELLOW/ADVISORY**	No activity since January 2			
2/25/2014	**YELLOW/ADVISORY**	Two explosions, ash cloud to 5 km (16,400 ft) ASL drifting west		Lightning detected on WWLN at 04:17 and 04:19 UTC January 24. Ash cloud observed in AVHRR Brightness Temperature Difference image. Satellite image analysis suggests cloud may have reached 8.2 km (26,903 ft) ASL	Ground coupled airwaves detected on the Korovin Volcano network consistent with 04:17 explosion from Cleveland. Second explosion at 10:35
3/6/2014	**YELLOW**	Multiple small puffs of ash and white steam from summit crater, rising less than 300 m (1,000 ft) above the summit	Yes	Observations from Nikolski residents	
3/7/2014	**YELLOW**		Yes		
3/9/2014	**YELLOW**		Yes		
5/5/2014	**YELLOW**			The summit crater has light gas emissions and some typically snow-free areas around the crater rim and inner slopes of the crater.	
6/5/2014	**YELLOW**	Explosion, possible ash cloud 140 km (87 mi) downwind at 11 pm AKST			09:20 explosion detected
06-08-14	**YELLOW**	Elevated surface temperature	Yes – weak		

Table 9. Summary of activity and observations at Cleveland volcano in 2014.—Continued

Date	Color code/ Alert level	Activity	Elevated surface temperatures, satellite sensor	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
06-09-14	**YELLOW**			Narrow, light-colored flowage deposit extends 1 km down western flank. Smaller flowage deposit on southern flank. Blocks up to 5 m visible as far as 1.3 km downslope of the summit crater on the eastern flank. Center of crater has a new 50-m-wide (164- ft-wide) pit. Likely related to June 5 explosion	
06-18-14	**YELLOW**			No major changes at the summit since June 9. Thick gas filled the summit crater on June 18	
06-23-14	**YELLOW**	Possible weakly elevated summit surface temperature	Yes	No major changes at the summit since June 9. Thick gas filled the summit crater on June 18	
06-28-14	**YELLOW**	Possible weakly elevated summit surface temperature	Yes		
07-02-14	**YELLOW**	No activity		Thick gas fills the summit crater. The entire edifice is now snow-free	
07-07-14	**YELLOW**	Weakly elevated summit surface temperature			
07-20-14	**YELLOW**	Elevated summit surface temperature	Yes	Landsat-8 July 20, 2014, 8:53 UTC SWIR data shows elevated temperatures in the summit crater. The hottest pixel is about 300 °C from a small part of the summit crater	
07-21-14	**YELLOW**	Weakly elevated summit surface temperature	Yes		
07-25-14	**YELLOW**	Degassing (?)		Thick gas fills the summit crater	
07-26-14	**YELLOW**	Elevated Temperatures	Yes, MODIS and AVHRR		
07-27-14	**YELLOW**	Elevated summit surface temperature			
07-28-14	**YELLOW**	Elevated summit surface temperature			
07-29-14	**YELLOW**	Elevated summit surface temperature			
07-30-14	**YELLOW**	Elevated summit surface temperature			

Table 9. Summary of activity and observations at Cleveland volcano in 2014.—Continued

Date	Color code/ Alert level	Activity	Elevated surface temperatures, satellite sensor	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
07-31-14	**YELLOW**	Elevated summit surface temperature			
08-01-14	**YELLOW**	Elevated summit surface temperature			
08-10-14	**YELLOW**				Cleveland seismic network and Web camera on line
08-17-14	**YELLOW**	Plume			
08-17-14	**YELLOW**	Elevated surface temperatures; steam/gas plume from summit			
08-19-14	**YELLOW**	Regional Swarm		Thick gas fills the summit crater	
08-25-14	**YELLOW**	Thick Fume			
08-27-14	**YELLOW**	Possible rockfall			
08-28-14	**YELLOW**	Possible rockfall			
08-29-14	**YELLOW**	Faint steam and gas plume, 20 km (12.4 mi) in length			
09-01-14	**YELLOW**	Elevated surface temperatures	Yes, several images		
09-02-14	**YELLOW**	Elevated surface temperatures	Yes, several images		
09-03-14	**YELLOW**	Elevated surface temperatures	Yes, several images	Light gas emissions from fumaroles along the east crater floor in the summit crater	
09-04-14	**YELLOW**	Elevated surface temperatures	Yes, several images		
09-07-14	**YELLOW**				
09-11-14	**YELLOW**	Rockfall signals			
09-15-14	**YELLOW**			Light gas emissions from fumaroles along the floor in the summit crater	
09-21-14	**YELLOW**	Elevated surface temperatures; steam/gas plume from summit	Yes, several images		
09-22-14	**YELLOW**	Elevated surface temperatures	Yes, several images		
09-23-14	**YELLOW**	Elevated surface temperatures	Yes, several images		

Table 9. Summary of activity and observations at Cleveland volcano in 2014.—Continued

Date	Color code/ Alert level	Activity	Elevated surface temperatures, satellite sensor	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
09-24-14	**YELLOW**	Steam/gas plume from summit			
09-28-14	**YELLOW**	Elevated surface temperatures	Yes, several images		
09-30-14	**YELLOW**			Continued fumarolic emissions from summit crater. Ground just outside crater on southern flank is snow-free	
10-02-14	**YELLOW**	Steam/gas plume from summit			Local seismicity, possibly from Cleveland
10-03-14	**YELLOW**	Elevated surface temperatures; steam/gas plume from summit	Yes, several images		
10-05-14	**YELLOW**	Elevated surface temperatures	Yes, several images		
10-13-14	**YELLOW**	Steam/gas plume from summit			
10-14-14	**YELLOW**	Elevated surface temperatures	Several images have elevated temperatures		
10-15-14	**YELLOW**				
11-12-14	**YELLOW**	Robust steam plume from summit; possible volcanic infrasound signal			
11-20-14	**YELLOW**	Steam/gas plume from summit	Several images have weakly elevated temperatures	Bare ground around summit crater	
11-24-14	**YELLOW**	New lava extrusion in summit crater; date of extrusion uncertain		Lava flow in summit crater about 30 m (98 ft) across. May have appeared as early as November 16	No seismicity associated with extrusion noted
12-02-14	**YELLOW**	Slow lava effusion continues		Lava flow about 45 m (148 ft) across	
12-03-14	**YELLOW**	Weak steam/gas plume from summit			
12-05-14	**YELLOW**	Weak steam/gas plume from summit			
12-06-14	**YELLOW**	Elevated surface temperatures	Several images have weakly elevated temperatures		

Table 9. Summary of activity and observations at Cleveland volcano in 2014.—Continued

Date	Color code/ Alert level	Activity	Elevated surface temperatures, satellite sensor	Ground, air, or other satellite observations	Seismic network and infrasound detection or other alarm triggers
12-07-14	**YELLOW**	Elevated surface temperatures	One image weak thermal feature		
12-19-14	**YELLOW**	Elevated surface temperatures	One image weak thermal feature		

Table 10. Cleveland volcano explosive events as detected by infrasound signals from December 25, 2011 to December 31, 2014.

[Identification of events and catalog maintenance by Matt Haney, USGS/AVO. 2014 events discussed in this report are shown in **bold**]

Date	Time (UTC)	Infrasonic event No.
12-25-11	1213	1
12-25-11	1532	2
12-29-11	1312	3
03-08-12	0405	4
03-10-12	0150	5
03-13-12	2255	6
04-04-12	0912	7
04-07-12	0035	8
04-07-12	0526	9
04-13-12	1604	10
04-13-12	1901	11
04-19-12	1238	12
05-04-12	1854	13
05-05-12	0920	14
06-04-12	1008	15
06-19-12	2204	16
06-26-12	1119	17
07-12-12	0552	18
08-04-12	1638	19
08-17-12	0848	20
08-20-12	0255	21
11-10-12	2025	22
05-04-13	1259	23
05-06-13	0723	24
05-06-13	1600	25
05-06-13	2030	26
10-02-13	1225	27
10-03-13	1912	28
10-04-13	0123	29
11-26-13	0431	30
12-28-13	2129	31
12-31-13	0406	32
01-02-14	**0334**	**33**
02-25-14	**0417**	**34**
02-25-14	**1035**	**35**
06-05-14	**0608**	**36**
11-06-14	**0742**	**37**

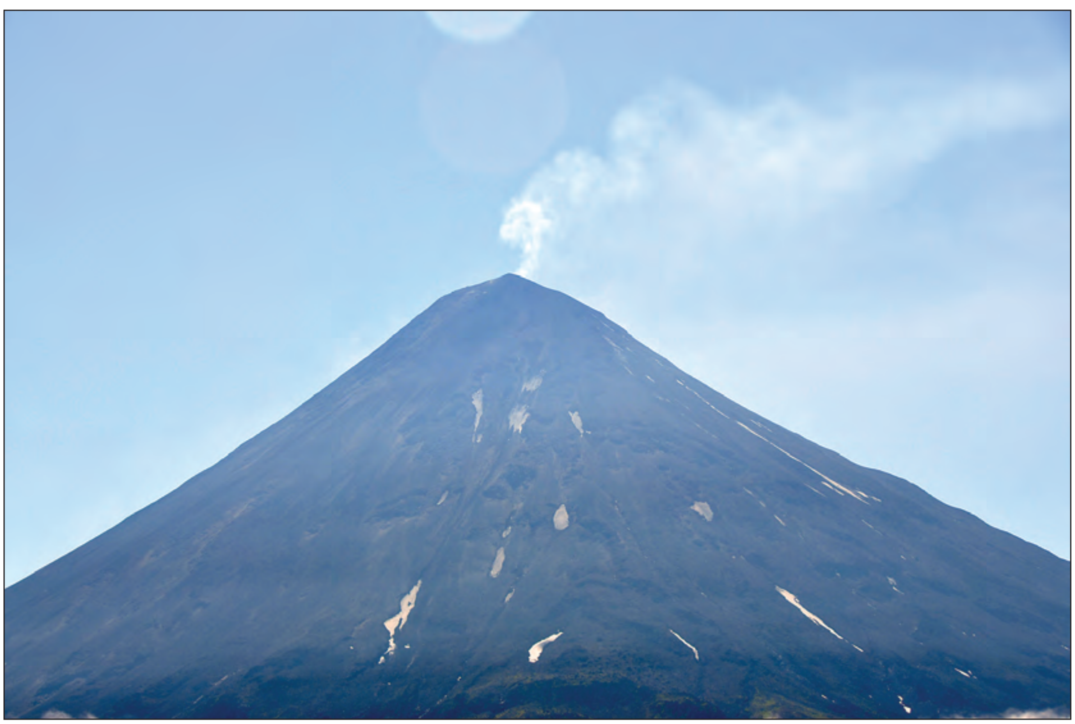

Figure 30. Typical gas and steam plume visible above the summit crater of Mount Cleveland during July–August 2014. Photograph by Christina Neal, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=67181.

Figure 31. Aerial view looking down into the summit crater of Mount Cleveland. North at top of image. Note native sulfur deposits and funnel-shaped inner crater. The walls and steeply sloping floor of the crater are mantled with recent ejecta. Also note fume emanating primarily from the lowest spot on the crater floor, marking the top of the conduit. Photograph by Pavel Izbekov, UAFGI/AVO, July 29, 2014. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66881.

Although no significant ash fallout or effects occurred as a result of the small explosions in 2014, satellite and field observations confirmed that the June 5 event produced pyroclastic avalanches down the western and southern flanks of the volcano, extending as much as 1 km (about 0.6 mi) from the crater rim. Large ballistics were thrown and rolled as far as 1.3 km (0.8 mi) from the summit. Following the June 5 event, satellite imagery showed that a 50-m-wide (160-ft-wide) hole marking the vent was visible in the center of the summit crater.

Field observers in late July and in August noted a handful of small rockfalls down the northeastern flank of Cleveland; later seismic evidence of these rockfalls was clear on monitoring station CLES (fig. 32). Given the steepness of the upper flanks of the volcano and the unstable carapace of recently erupted, fragmental debris, frequent rockfalls are not surprising and, in fact, are expected. Additionally, depending on viewing and atmospheric conditions, a slow-moving blue-tinted plume was observed rising from the summit crater. Occasionally, this plume was more voluminous and robust. One evening, Max Kaufman of AVO was camped at Concord Point and observed a faint glow in clouds over the summit crater, indicating temperatures high enough to produce incandescence (that is, the presence of lava).

Satellite observations in late November detected a new lava dome in the summit crater, although no seismicity related to this extrusion was noted on the two on-island stations. The extrusion of lava was consistent with an open conduit and transport of magma stored high in the conduit to the surface. The new lava flow was about 30 m (100 ft) across on November 24, and may have appeared at the surface as early as November 16. Retrospective analysis of seismic and infrasound data from the two Chuginadak monitoring stations in January 2015 indicated that a single explosive event occurred on November 6, and could have heralded the subsequent effusion of lava (John Lyons, USGS/AVO, written commun., January 2015). Non-explosive, aseismic effusion continued and, when next noted in satellite images on December 2, the lava flow was about 45 m (150 ft) across. For the remainder of the year, based on current analysis, no explosions occurred and only occasional, weak thermal signals were noted at the summit in clear or partly cloudy satellite images. The lava dome in the summit crater showed some sign of collapse in its center, but remained largely unchanged into 2015.

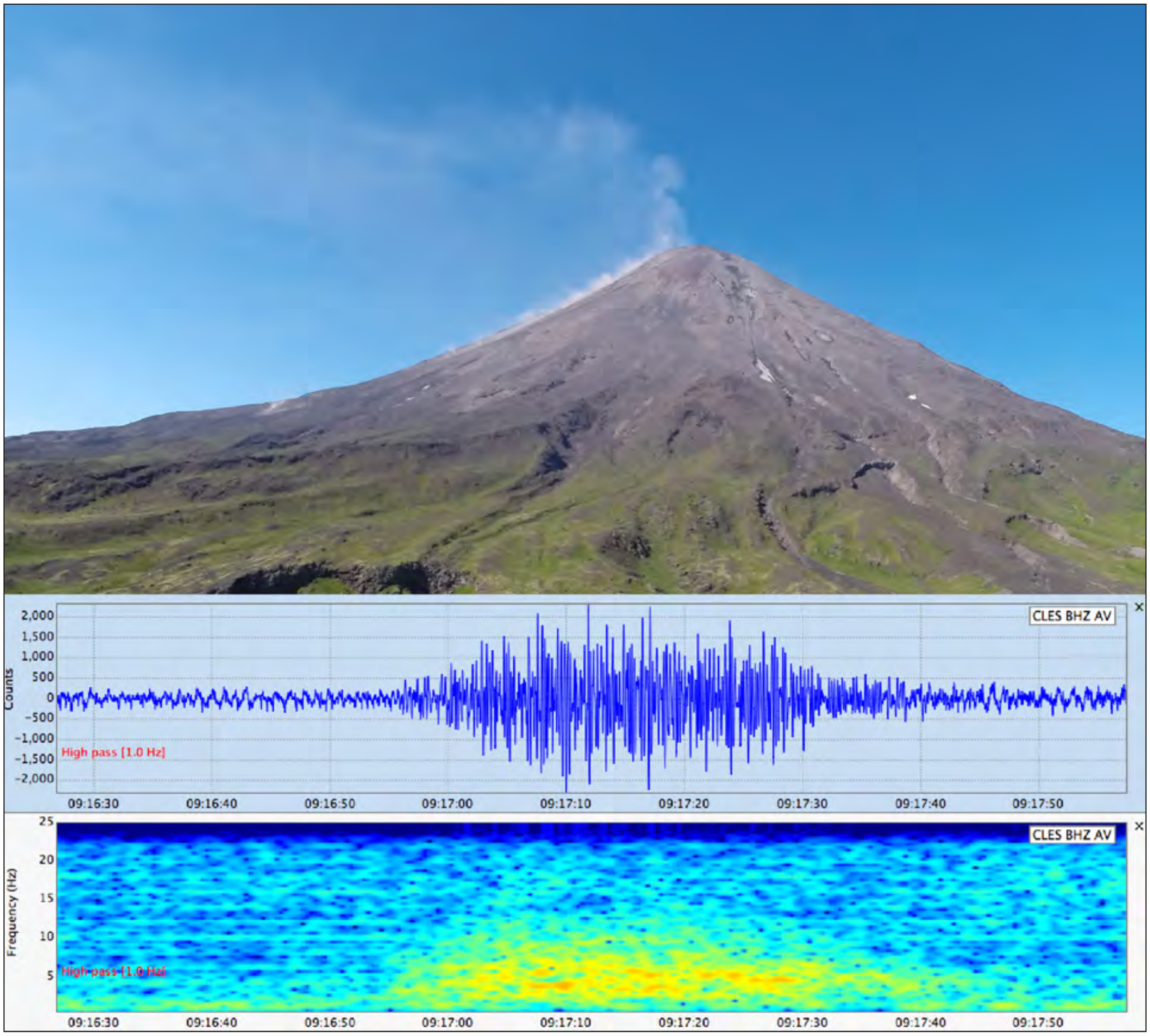

Figure 32. Photograph and seismographs of small rockfall at Cleveland volcano and the associated seismic signal on station CLES. Image credit John Lyons, USGS/AVO and Christina Neal, USGS. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=67741.

Analysis of seismicity from the two Chuginadak monitoring stations suggests a low background rate of local earthquakes at Cleveland during its current phase of intermittent eruption and low-level unrest.

The 2014 Islands of Four Mountains (IFM, including the volcanoes Tana, Cleveland, Herbert, and Carlisle) field campaign was multi-disciplinary and included components of archaeology, paleoecology, tsunami studies, geomorphology, and volcanology. In addition to the establishment of seismic, infrasound, and Web camera monitoring, AVO also recorded GPS positions of four benchmarks on Chuginadak Island. Results of the field and associated laboratory work are still in progress, and a second season of fieldwork occurred in 2015. Notable geologic discoveries and accomplishments included:

- Previously unknown boiling point fumaroles and hot springs and first known sampling of thermal waters at Tana Volcano (fig. 33);
- Documentation and sampling of recent Cleveland juvenile ejecta (fig. 34);
- Radiocarbon dating of soils interleaved with prominent IFM tephras (figs. 35 and 36);
- Reconnaissance geologic mapping and sampling of Tana, Cleveland, Herbert, and Carlisle lavas and tephras (fig. 37); and
- Collection of hundreds of high resolution photographic images of IFM volcanoes, including close-up images of the Cleveland summit crater and lava dome.

Figure 33. Aerial photograph of Tana volcano, a little-known, complex, Holocene volcano forming the eastern part of Chuginadak Island, July 29, 2014. Volcano contains newly discovered boiling-point hot springs near its summit and along the eastern coastline. Initial geologic studies indicate that Holocene eruptive activity has occurred; it appears that the most recent eruptions have taken place on the westernmost part of the edifice. Photograph by John Lyons, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=68861.

Figure 34. Photograph of a recently erupted bomb ejected from Mount Cleveland volcano, August 4, 2014. This bomb tumbled down the southern slope of the volcano in a pyroclastic avalanche. Professor Kirsten Nicolaysen, Whitman College, stands next to bomb for scale. Photograph by Christina Neal, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66911.

Figure 35. Photograph of part of an approximately 6-meter-thick section of one of many tephra fall and other deposits related to eruptive activity at Mount Cleveland and other nearby volcanoes, August 15, 2014. Preliminary radiocarbon dating results suggest the lowest unit (here labeled "CC") is more than 9,000 years old (Christina Neal, USGS/AVO, unpub. data, 2014). Photograph by Pavel Izbekov, UAFGI/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=70691.

Mount Cleveland forms the western part of Chuginadak Island, a remote and uninhabited island in the east-central Aleutians. Cleveland is located about 75 km (45 mi) west of the community of Nikolski, and 1,500 km (940 mi) southwest of Anchorage. Cleveland volcano has been in intermittent eruption since its last significant eruption in 2001, when three explosive events generated ash clouds as high as 11,800 m (39,000 ft) ASL. The 2001 eruption also produced a lava flow and hot avalanche that reached the sea (Dean and others, 2004; McGimsey and others, 2007; Neal and others, 2009; McGimsey and others, 2011, 2014; Neal and others, 2011, 2014; Herrick and others, 2014; Dixon and others, 2015). In the past 15 years, Cleveland has been intermittently active, producing small lava flows often followed by explosions that generate small ash clouds that generally do not exceed an altitude of 6,100 m (20,000 ft) ASL. These explosions also launch debris onto the slopes of the cone, producing hot pyroclastic avalanches and lahars that sometimes reach the coastline.

Figure 36. Photograph of tephra fall and other pyroclastic and reworked pyroclastic deposits atop coastal bluff on southeastern shoreline of Carlisle Volcano, August 11, 2014. Provenance of tephras remains uncertain and awaits further geochemical, geochronologic, and field studies. Photograph by Christina Neal, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=67131.

Figure 37. Photograph showing aerial view of the summit crater of Herbert volcano. Cleveland volcano is in the distance, 14 km (8.7 mi) northeast of Herbert. Very little is known geologically about Herbert; only a single grab-sample of lava is known to have been collected. Fumarolic field at the far shoreline of this summit crater lake emerged from beneath receding ice sometime before 2004. No mention of these fumaroles was made in the comprehensive account of Motyka and others (1993). To our knowledge, these fumaroles have never been sampled. Photograph by Pavel Izbekov, UAFGI/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=70651.

Kanaga Volcano

GVP # 311110

51°55'N 177°10'W
1,307 m (4,288 ft)

Kanaga Island, Delarof Islands, Aleutian Islands

EARTHQUAKE SWARM

A short lived swarm 5 km (3.1 mi) east-northeast of Kanaga Volcano (fig. 38) began on March 26, 2014, with 24 located earthquakes. The number and size of earthquake doubled the next day, and included earthquakes with magnitudes up to 1.1. On March 27, the swarm started to decrease in numbers and intensity, and by March 29 had ceased altogether. The total swarm encompassed 72 earthquakes large enough to locate. Subsequent satellite observations showed no changes at the summit following this short-lived earthquake swarm. The only other notable observation of Kanaga seismic data was the presence of 2–3 Hz monochromatic signals in late August through early September, which could be a sign of magma moving under the volcano. The Aviation Color Code and Volcano Alert Level remained at **GREEN/NORMAL** for all of 2014.

Kanaga Volcano is a symmetrical stratocone located on the northern end of Kanaga Island in the western Aleutian Islands, 33 km (21 mi) west of the community of Adak. Numerous eruptions have been recorded since the mid-1700s, with the most recent occurring in 2012 (Herrick and others, 2014). Active fumaroles persist in the summit region and hot springs occur near the base of the volcano. The AVO installed a seismic network on Kanaga in 1999.

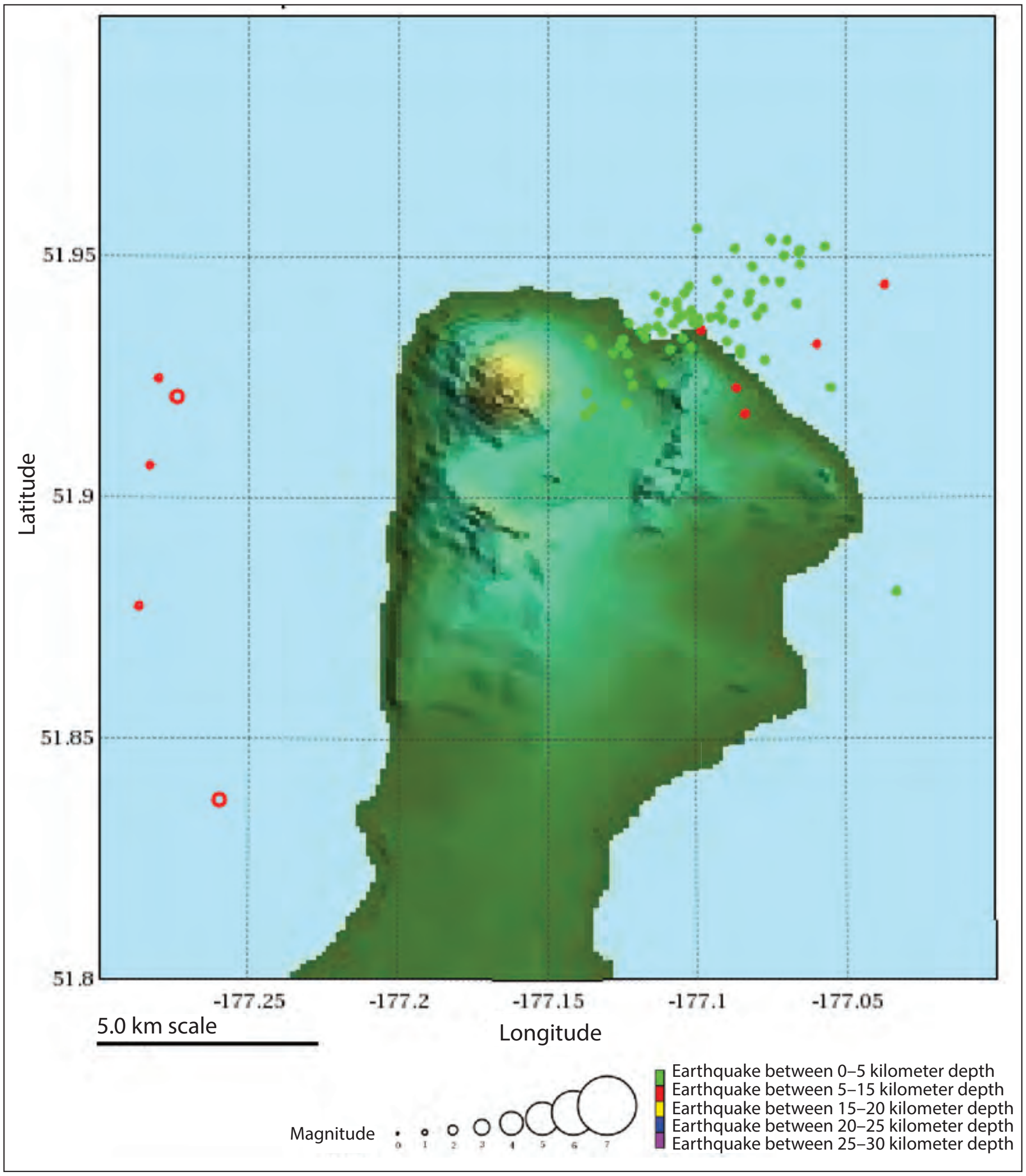

Figure 38. Map of Kanaga volcano, showing the epicenter locations of a short-lived earthquake swarm that occurred east-northeast of Kanaga Volcano in late March 2014. The majority of the earthquakes were shallower than 5 km (3.1 mi). AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95391.

Tanaga Volcano

GVP # 311080

51°53'N 178°09'W
1,806 m (5,925 ft)

Kanaga Island, Delarof Islands, Aleutian Islands

EARTHQUAKE SWARM

In February and March 2014, an earthquake swarm occurred about 13 km (8 mi) southwest of Tanaga Volcano (fig. 39). This was the most energetic volcano-tectonic swarm at Tanaga since 2005 (McGimsey and others, 2007). The elevated seismicity continued into the summer, although at a reduced rate, and ended in late 2014. The swarm comprised 80 percent of all earthquakes located on or near Tanaga during the year. The earthquakes were all less than M2.0 and occurred at crustal depths of 5–10 km (3–6 mi). No specific cause was determined for the short-lived swarm. Despite the swarm, the Aviation Color Code and Volcano Alert Level remained at **GREEN/NORMAL** for all of 2014.

Tanaga Volcano lies in the Andreanof Islands, about 100 km (62 mi) west of the community of Adak and 2,025 km (1,260 mi) southwest of Anchorage. Tanaga is the highest of three closely spaced, east-west aligned stratovolcanoes that make up the northwest end of Tanaga Island. The last reported eruption of Tanaga occurred in 1914, and earlier eruptions were reported in 1763–1770, 1791, and 1829 (Miller and others, 1998). Reports of these eruptions are vague, but deposits on the flanks of the volcano show that typical eruptions produce blocky lava flows and occasional ash clouds. Eruptions have occurred from the summit vent and from a 1,584-m (5,197-ft) high satellite vent on the northeastern flank of the volcano (Coombs and others, 2007).

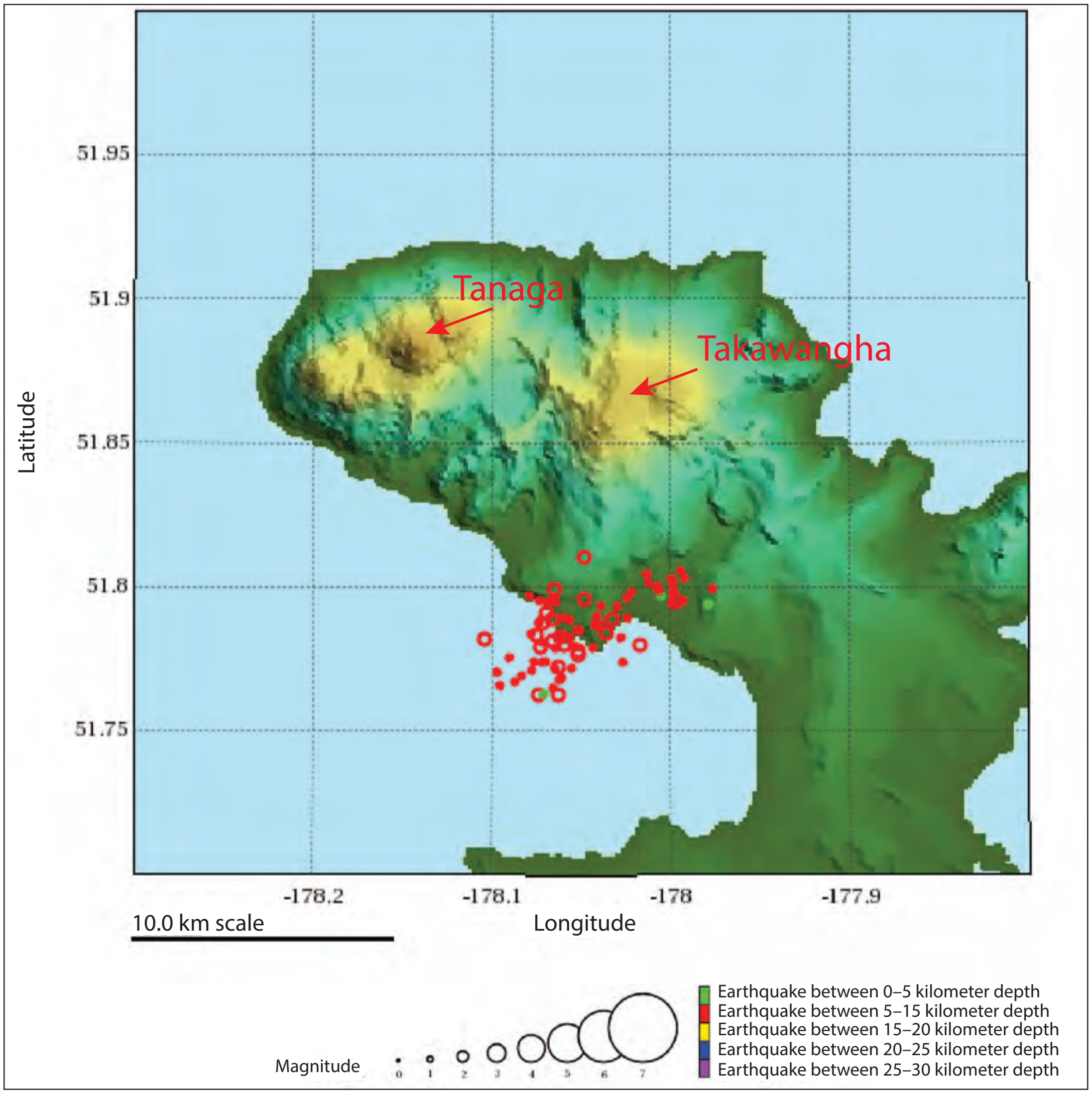

Figure 39. Map of the northern part of Tanaga Island, showing epicenter locations of the 79 earthquakes comprising a swarm of earthquakes spanning February and March 2014 with depths that ranged from 5 to 13 kilometers (3.1 to 8.1 miles). AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=95401.

Semisopochnoi Island

GVP # 311060

51°55'N 179°036'W
800 m (2,625 ft)

Rat Islands, Aleutian Islands

EARTHQUAKE SWARM RELATED TO MAGMATIC INTRUSION

Semisopochnoi ("Seven Peaks") Island is the largest young island in the western Aleutian Islands (fig. 40). An energetic earthquake swarm and deformation pulse occurred in 2014 that was strongly suggestive of magmatic intrusion. No eruptive activity ensued and AVO is unaware of any visible changes at the surface that occurred as a result of this activity. Activity was of sufficient severity that AVO upgraded the Aviation Color Code and Volcano Alert Level from **UNASSIGNED** to **YELLOW/ADVISORY** for the duration of the swarm, which lasted from about June 13 through September 4.

Low-frequency events at Semisopochnoi Island were first noted on June 1, 2014. Semisopochnoi's seismic network had been returned to service on May 22, 2014, only 2 weeks prior to these events. The swarm began on June 9 at about 18:00 UTC (10:00 a.m. AKDT), and the AVO network recorded about 40 volcanic-tectonic earthquakes over the next 2 days. These earthquakes were small (less than M2) and clustered around Mount Cerberus in the center of the caldera. Depths ranged from 2 to 10 km (1.2 to 6.2 mi).

Tremor was first noted on June 12, coincident with an increase in the rate of earthquakes recorded. Over the next day, the number of earthquakes doubled over the total located in the previous 3 days. The number of located earthquakes, all volcano-tectonic, doubled again on June 14, marking the peak daily earthquake count of the sequence (223 earthquakes). Throughout the increase in activity, the depth range of the events and epicentral area did not change. On June 13, AVO issued a VAN upgrading the Aviation Color Code and Volcano Alert Level to **YELLOW/ADVISORY** based on the ongoing swarm (fig. 41). Following the peak in earthquake activity on June 14, the number of located events decreased to 20–30 earthquakes located in the last week of June, and further decreases in seismicity continued into July and August.

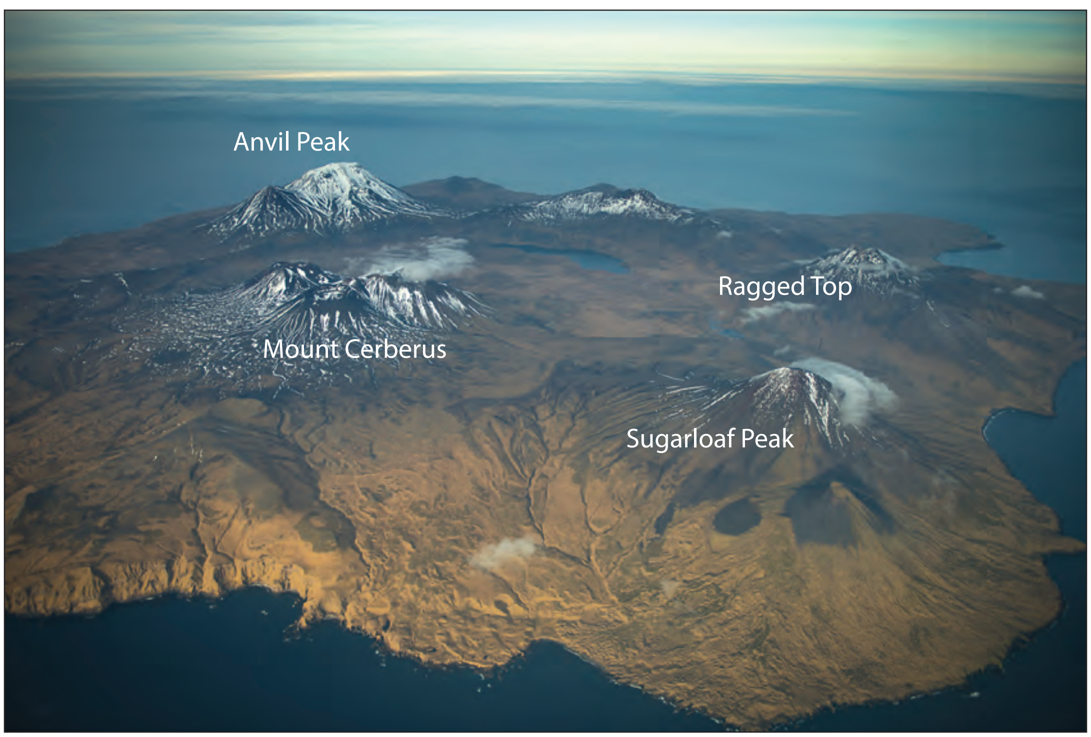

Figure 40. Aerial photograph looking northwest at Semisopochnoi Island and several of its stratocones, November 2012. Mount Cerberus and Sugarloaf Peak have had historical or suspected historical eruptions, and Anvil Peak and Ragged Top are Holocene. Photograph by Roger Clifford, used with permission. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=48001.

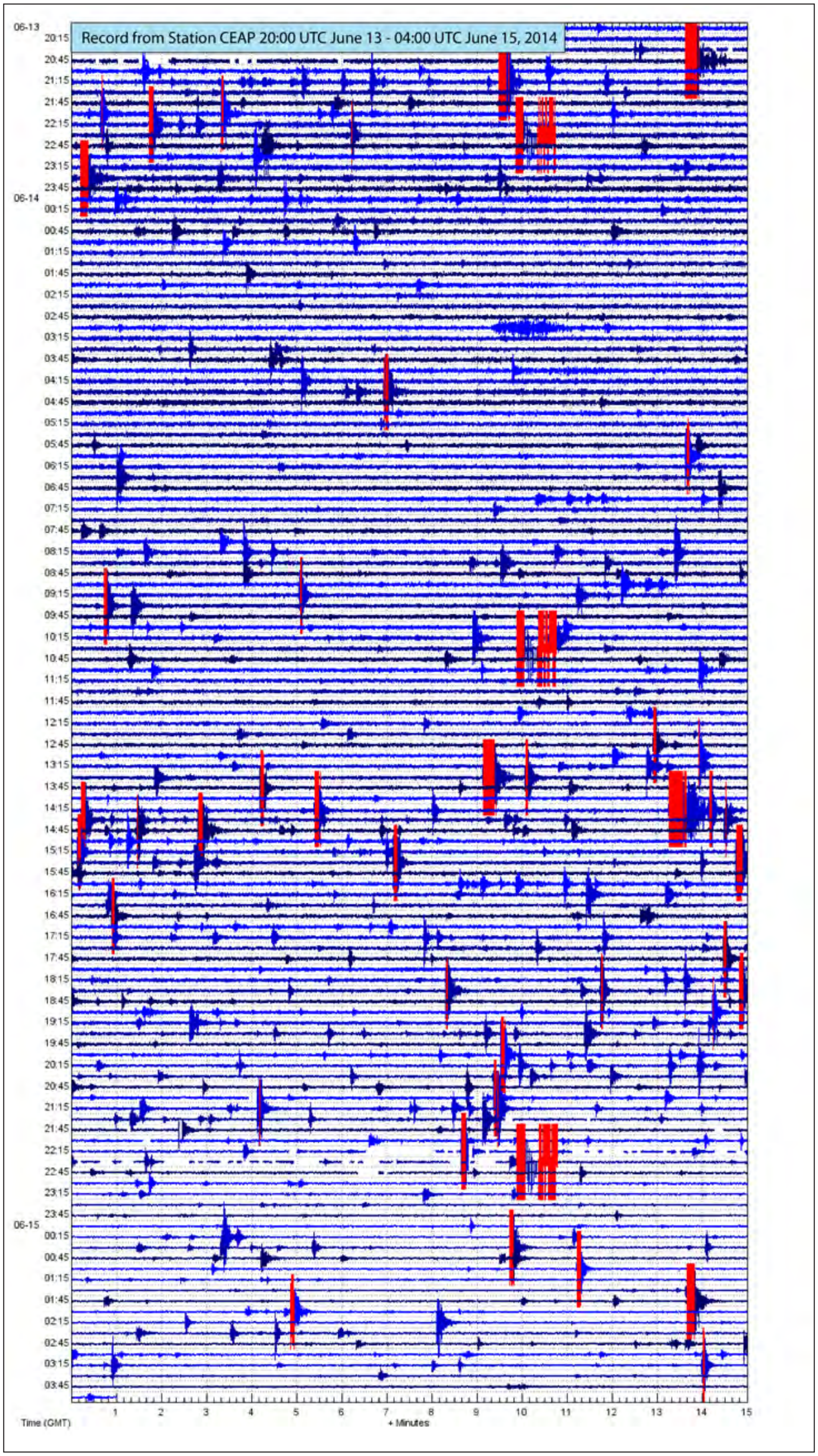

Figure 41. Helicorder record showing part of the swarm of volcano-tectonic earthquakes at Semisopochnoi Island from 20:00 UTC on June 13 to 04:00 UTC on June 15, 2014 (2:00 p.m. on June 13 to 8:00 p.m. AKDT on June 14, 2014). The largest number of located earthquakes (223) on 1 day in the swarm occurred on June 14, 2014. Epicenters covered much of the island. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=78921.

On June 23, a M7.9 earthquake occurred in the region, 73 km (46 mi) west of Semisopochnoi Island at a depth of 118 km (73 mi) in the subducting slab. It was accompanied by more than 2,500 aftershocks, 60 with magnitudes of 4.0 or greater (fig. 42). There was no direct causality between the M7.9 earthquake and the Semisopochnoi volcanic-tectonic earthquake (VT) swarm; AVO did not note any change in the rate of VT seismicity at Semisopochnoi following the M7.9 earthquake.

Zhong Lu of Southern Methodist University evaluated the deformation related to the volcanic unrest. More than 10 cm (4 in.) of inflation occurred between 2003 and June 26, 2014, about one-half of which occurred between June 15 and June 26, 2014. Maximum uplift was approximately in the center of the caldera. Modeled source depth ranges from 5 to 10 km (3 to 6 mi). (Zhong Lu, written commun., 2015).

The consensus interpretation of the 2014 swarm is that it represents an intrusion of magma. This would be consistent with the style and character of the seismic swarm as well as the deformation signal. Although the seismograph network was not operational before May 22, the absence of significant activity between May 22 and June 9 suggests that the intrusion occurred in mid-June. An earlier pulse of magma possibly was emplaced before May 22, but without an operational seismograph network, this cannot be verified.

In response to the swarm, AVO instituted heightened seismic watch schedules, requested that NOAA initiate HYSPLIT model ash cloud trajectory runs, and solicited pilots and the U.S. Coast Guard to report any unusual volcanic activity (such as steaming or ground cracks). Daily satellite analysis by AVO staff included careful examination of the volcano using all available imagery. Throughout the sequence, no surface activity was noted in the few clear-weather views of the island. The volcano is remote, and aerial reconnaissance by AVO staff was determined to be too costly to obtain.

The 2014 unrest was the first significant departure from background at Semisopochnoi since installation of the seismic network in 2005. Background seismicity at Semisopochnoi had been relatively low (fewer than 50 earthquakes located per year until 2014), with short periods of weak seismic tremor. The last confirmed eruption at Semisopochnoi was from a satellitic vent in 1987 (Miller and others, 1998). The volcano, however, was deforming. Lu and Dzurisin (2014) discovered an area about 2 km (1.2 mi) in diameter that subsided during 2004–2010 at a rate of about 10 mm/yr (0.4 in/yr).

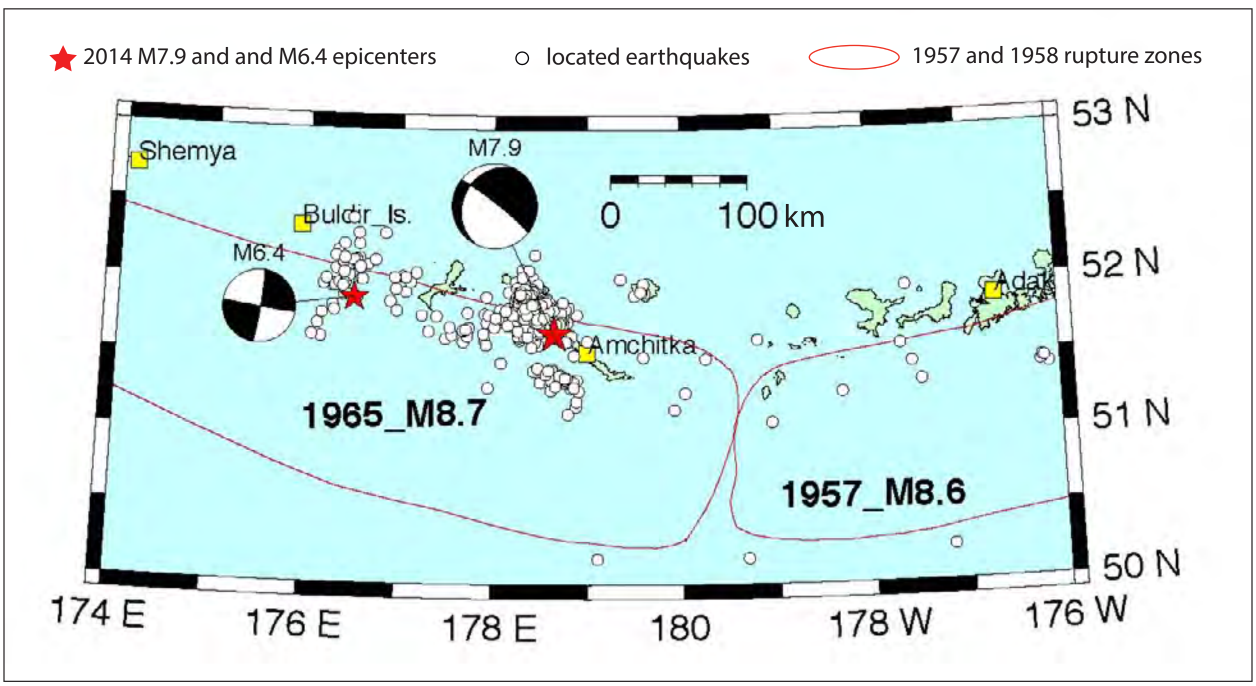

Figure 42. Map of earthquake epicenters near Semisopochnoi Island during 2014. A M7.9 earthquake occurred 73 kilometers from Semisopochnoi Island during the 2014 Semisopochnoi earthquake swarm, in the source zone of the 1965 M8.7 Rat Island earthquake. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=80831.

They suggested compaction of young volcanic deposits in the caldera as a mechanism to explain this subsidence; alternative hypotheses include localized subsidence due to depressurization of a shallow hydrothermal system or localized changes in the groundwater table.

Semisopochnoi volcano is part of the largest, young volcanic island in the western Aleutians. The volcano is dominated by an 8-km (5-mi) diameter caldera that contains a small lake and numerous post-caldera cones and craters (Coats, 1959; Michelle Coombs, USGS/AVO, written commun., 2015). Warm springs downstream of the outlet of Fenner Lake (fig. 43) attest to ongoing heat discharge through the caldera floor. The age of the caldera is not known with certainty but likely is early Holocene; preliminary field evidence suggests that caldera-forming deposits are found on all quadrants of the island (Michelle Coombs and Jessica Larsen, USGS/AVO, written commun., 2015). Radiocarbon dates on tephra from nearby Amchitka Island tentatively associated with the caldera-forming eruption of Semisopochnoi Island suggest a maximum age of 6,920 radiocarbon years BP (figs. 44 and 45; Michelle Coombs, USGS/AVO, written commun., 2015). Since caldera formation, a number of post-caldera vents scattered about the caldera floor and on the southern flank have been active. The last known eruption at Semisopochnoi occurred in 1987, probably from Sugarloaf Peak on the south coast of the island, but details are scant (Reeder, 1990). Mount Cerberus, a three-peaked cone cluster in the southwestern part of the caldera, is another prominent, young post-caldera landform.

Figure 43. Photograph of warm springs downstream of the outlet of Fenner Lake inside Semisopochnoi caldera, September 26, 2005. Photograph by Michelle Coombs, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66291.

Figure 44. Aerial photograph of caldera-forming deposits exposed in the southern coastline of Semisopochnoi Island, September 11, 2005. Photograph by Michelle Coombs, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=66191.

Figure 45. Photograph of tephra deposits on Amchitka Island, about 45 kilometers (28 miles) south of Semisopochnoi Island, September 15, 2005. Prominent tri-colored deposit is suspected to be tephra fallout related to the caldera-forming eruption of Semisopochnoi volcano, but this is as-yet unconfirmed by geochemistry. Photograph by Christina Neal, USGS/AVO. AVO database image URL: http://www.avo.alaska.edu/images/image.php?id=4609.

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References Cited

Bacon, C.R., Neal, C.A., Miller, T.P., McGimsey, R.G., and Nye, C.J., 2014, Postglacial eruptive history, geochemistry, and recent seismicity of Aniakchak Volcano, Alaska: U.S. Geological Survey Professional Paper 1810, 74 p., http://dx.doi.org/10.3133/pp1810.

Bacon, C.R., Sisson, T.W., and Mazdab, F.K., 2007, Young cumulate complex beneath Veniaminof caldera, Aleutian arc, dated by zircon in erupted plutonic blocks: Geology, v. 35, no. 6, p. 491–494, doi:10.1130/G23446A.1.

Begét, J.E., Larsen, J.F., Neal, C.A., Nye, C.J., and Schaefer, J.R., 2005, Preliminary volcano-hazard assessment for Okmok Volcano, Umnak Island, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2004-3, 32 p., 1 sheet, scale 1:150,000.

Black, R.F., 1975, Late-Quaternary geomorphic processes—Effects on the ancient Aleuts of Umnak Island in the Aleutians: Arctic, v. 28, n. 3, p. 159–169.

Byers, F.M., Jr., 1959, Geology of Umnak and Bogoslof Islands, Aleutian Islands, Alaska, in Investigations of Alaskan volcanoes: U.S. Geological Survey Bulletin B 1028-L, p. 267–369, 5 sheets, scale 1 at 1:63,360, 1 at 1:96,000, and 1 at 1:300,000.

Cameron, C.E., Nye, C.J., and Neal, C.A., 2008, Counting Alaska volcanoes [abs.]: Eos Transactions, American Geophysical Union, Fall Meeting, abstract V43H-07.

Cameron, C.E., ed., 2005, Alaska Volcano Observatory Web site, accessed November 12, 2015, at http://www.avo.alaska.edu.

Coats, R.R., 1959, Geologic reconnaissance of Semisopochnoi Island, western Aleutian Islands, Alaska, *in* Investigations of Alaskan volcanoes: U.S. Geological Survey Bulletin B 1028-O, p. 477–519, 1 sheet, scale 1:25,000.

Coombs, M.L., McGimsey, R.G., and Browne, B.L., 2007, Preliminary volcano-hazard assessment for the Tanaga Volcanic Cluster, Tanaga Island, Alaska: U.S. Geological Survey Scientific Investigations Report 2007-5094, 36 p., http://pubs.usgs.gov/sir/2007/5094/.

Coombs, M.L., Neal, C.A., Wessels, R.L., and McGimsey, R.G., 2006, Geothermal disruption of summit glaciers at Mount Spurr Volcano, 2004–6—An unusual manifestation of volcanic unrest: U.S. Geological Survey Professional Paper 1732-B, 33 p., http://pubs.usgs.gov/pp/pp1732/pp1732b.

De Angelis, Silvio, Fee, David, Haney, Matthew, and Schneider, David, 2012, Detecting hidden volcanic explosions from Mt. Cleveland volcano, Alaska, with infrasound and ground-coupled airwaves: Geophysical Research Letters, v. 39, L21312, 6 p., doi:10.1029/2012GL053635.

Dean, K.G., Dehn, Jonathan, Papp, K.R., Smith, Steve, Izbekov, Pavel, Peterson, Rorik, Kearney, Courtney, and Steffke, Andrea, 2004, Integrated satellite observations of the 2001 eruption of Mt. Cleveland, Alaska: Journal of Volcanology and Geothermal Research, v. 135, p. 51–73.

Dixon, J.P., Cameron, Cheryl, McGimsey, R.G., Neal, C.A., and Waythomas, Chris, 2015, 2013 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2015–5110, 92 p., http://dx.doi.org/10.3133/sir20155110.

Dreher, S.T., Eichelberger, J.C., and Larsen, J.F., 2005, The petrology and geochemistry of the Aniakchak caldera-forming ignimbrite, Aleutian Arc, Alaska: Journal of Petrology, v. 46, n. 9, p. 1,747–1,768, doi:10.1093/petrology/egi032.

Fee, D., Steffke, A., and Garces, M., 2010, Characterization of the 2008 Kasatochi and Okmok eruptions using remote infrasound arrays: Journal of Geophysical Research, v. 115, D00L10, 15 p., doi:10.1029/2009JD013621.

Fierstein, Judy, and Hildreth, Wes, 2001, Preliminary volcano-hazard assessment for the Katmai volcanic cluster, Alaska: U.S. Geological Survey Open-File Report 00–0489, 50 p., 1 pl., scale not applicable, https://pubs.usgs.gov/of/2000/0489/.

Freymueller, J.T., and Kaufman, A.M., 2010, Changes in the magma system during the 2008 eruption of Okmok volcano, Alaska, based on GPS measurements: Journal of Geophysical Research, v. 115, B12415, 14 p., doi:10.1029/2010JB007716.

Gardner, C.A., and Guffanti, M.C., 2006, U.S. Geological Survey's alert notification system for volcanic activity: U.S. Geological Survey Fact Sheet 2006-3139, 4 p., http://pubs.usgs.gov/fs/2006/3139/.

Hadley, David, Hufford, G.L., and Simpson, J.J., 2004, Resuspension of relic volcanic ash and dust from Katmai: Still an aviation hazard: Weather and Forecasting, v. 19, n. 5, p. 829–840.

Herrick, J.A., Neal, C.A., Cameron, C.E., Dixon, J.P., and McGimsey, R.G., 2014, 2012 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2014–5160, 82 p., http://dx.doi.org/10.3133/sir20145160.

Keith, T.E.C., ed., 1995, The 1992 eruptions of Crater Peak Vent, Mount Spurr volcano, Alaska: U.S. Geological Survey Bulletin B 2139, 220 p.

Larsen, J.F., Neal, Christina, Schaefer, Janet, Begét, Jim, and Nye, Chris, 2007, Late Pleistocene and Holocene caldera-forming eruptions of Okmok Caldera, Aleutian Islands, Alaska, *in* Eichelberger, John, Gordeev, Evgenii, Izbekov, Pavel, Kasahara, Minoru, and Lees, Jonathan, eds., Volcanism and subduction—The Kamchatka region: American Geophysical Union, Geophysical Monograph 172, p. 343–364.

Lu, Zhong, 2007, InSAR imaging of volcanic deformation over cloud-prone areas—Aleutian Islands: Photogrammetric Engineering and Remote Sensing, v. 73, no. 3, p. 245–257.

Lu, Zhong, and Dzurisin, Daniel, 2014, InSAR imaging of Aleutian volcanoes: Chichester, United Kingdom, Springer-Praxis, 390 p.

Lu, Zhong, Wicks, Charles, Jr., Power, J.A., and Dzurisin, Daniel, 2000, Ground deformation associated with the March 1996 earthquake swarm at Akutan volcano, Alaska, revealed by satellite radar interferometry: Journal of Geophysical Research, v. 105, no. B9, p. 21,483–21,496.

McGimsey, R.G., Maharrey, J.Z., and Neal, C.A., 2014, 2011 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2014–5159, 50 p., http://dx.doi.org/10.3133/sir20145159.

McGimsey, R.G., and Neal, C.A., 1996, 1995 Volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 96–0738, 22 p.

McGimsey, R.G., Neal, C.A., Dixon, J.P., Malik, Nataliya, and Chibisova, Marina, 2011, 2007 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2010-5242, 110 p., http://pubs.usgs.gov/sir/2010/5242/.

McGimsey, R.G., Neal, C.A., Dixon, J.P., and Ushakov, Sergey, 2007, 2005 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2007–5269, 94 p., http://pubs.usgs.gov/sir/2007/5269/.

McGimsey, R.G., Neal, C.A., and Doukas, M.P., 1995, Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory, 1992: U.S. Geological Survey Open-File Report 95–83, 26 p.

McGimsey, R.G., Neal, C.A., and Girina, Olga, 2003, 1998 Volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 03–423, 35 p.

McGimsey, R.G., Neal, C.A., and Girina, Olga, 2004a, 1999 Volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004–1033, 49 p.

McGimsey, R.G., Neal, C.A., and Girina, Olga, 2004b, 2001 volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004–1453, 53 p.

McGimsey, R.G., Neal, C.A., and Girina, Olga, 2005, 2003 volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory—U.S. Geological Survey Open-File Report 2005–1310, 62 p., http://pubs.usgs.gov/of/2005/1310/.

McGimsey, R.G., Neal, C.A., Girina, O.A., Chibisova, Marina, and Rybin, Alexander, 2014, 2009 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2013–5213, 125 p., http://dx.doi.org/10.3133/sir20135213.

McGimsey, R.G., and Wallace, K.L., 1999, 1997 Volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 99–0448, 42 p.

Miller, T.P., and Chouet, B.A., 1994, The 1989–1990 eruptions of Redoubt volcano—An introduction, *in* Miller, T.P., and Chouet, B.A., eds., The 1989–1990 eruptions of Redoubt Volcano, Alaska: Journal of Volcanology and Geothermal Research, v. 62, no. 1, p. 1–10.

Miller, T.P., McGimsey, R.G., Richter, D.H., Riehle, J.R., Nye, C.J., Yount, M.E., and Dumoulin, J.A., 1998, Catalog of the historically active volcanoes of Alaska: U.S. Geological Survey Open-File Report 98–582, 104 p.

Miller, T.P., and Smith, R.L., 1987, Late Quaternary caldera-forming eruptions in the eastern Aleutian arc, Alaska: Geology, v. 15, no. 5, p. 434–438.

Mogi, K., 1958, Relations between the eruptions of various volcanoes and the deformations of the ground surface around them: Bulletin of the Earthquake Research Institute, v. 36, p. 99–134.

Motyka, R.J., Liss, S.A., Nye, C.J., and Moorman, M.A., 1993, Geothermal resources of the Aleutian Arc: Alaska Division of Geological & Geophysical Surveys Professional Report PR 0114, 17 p., 4 sheets, scale 1:1,000,000.

Motyka, R.J., Moorman, M.A., and Liss, S.A., 1981, Assessment of thermal springs sites, Aleutian Arc, Atka Island to Becharof Lake—Preliminary results and evaluation: Alaska Division of Geological & Geophysical Surveys Open-File Report AOF 0144, 173 p.

Motyka, R.J., Nye, C.J., Turner, D.L., and Liss, S.A., 1993, The Geyser Bight geothermal area, Umnak Island, Alaska: Geothermics, v. 22, no. 4, p. 301–327.

Neal, C.A., Doukas, M.P., and McGimsey, R.G., 1995, 1994 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 95–0271, 20 p.

Neal, C.A., Herrick, J., Girina, O.A., Chibisova, M., Rybin, A., McGimsey, R.G., and Dixon, J., 2014, 2010 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2014–5034, 76 p., http://dx.doi.org/10.3133/sir20145034.

Neal, C.A., and McGimsey, R.G., 1997, 1996 volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 97–0433, 34 p.

Neal, C.A., McGimsey, R.G., and Chubarova, Olga, 2004, 2000 Volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004–1034, 37 p.

Neal, C.A., McGimsey, R.G., Dixon, J.P., Cameron, C.E., Nuzhaev, A.A., and Chibisova, Marina, 2011, 2008 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2010-5243, 94 p., http://pubs.usgs.gov/sir/2010/5243/.

Neal, C.A., McGimsey, R.G., Dixon, J.P., Manevich, Alexander, and Rybin, Alexander, 2009, 2006 Volcanic activity in Alaska, Kamchatka, and the Kurile Islands—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Scientific Investigations Report 2008–5214, 102 p., http://pubs.usgs.gov/sir/2008/5214/.

Neal, C.A., McGimsey, R.G., Dixon, J.P., and Melnikov, Dimitry, 2005, 2004 Volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2005–1308, 71 p., http://pubs.usgs.gov/of/2005/1308/.

Neal, C.A., McGimsey, R.G., and Doukas, M.P., 1996, 1993 Volcanic activity in Alaska—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 96–0024, 21 p.

Neal, C.A., McGimsey, R.G., and Girina, Olga, 2005, 2002 Volcanic activity in Alaska and Kamchatka—Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004–1058, 55 p., http://pubs.usgs.gov/of/2004/1058/.

Neal, C.A., McGimsey, R. G., Miller, T. P., Riehle, J. R., and Waythomas, C. F., 2001, Preliminary volcano-hazard assessment for Aniakchak Volcano, Alaska: U.S. Geological Survey Open-File Report 2000–519, 35 p.

Nicholson, R.S., Gardner, J.E., and Neal, C.A., 2011, Variations in eruption style during the 1931 A.D. eruption of Aniakchak volcano, Alaska: Journal of Volcanology and Geothermal Research, doi:10.1016/j.jvolgeores.2011.08.002.

Nye, C. J., Motyka, R. J., Turner, D. L., and Liss, S. A., 1992, Geology and geochemistry of the Geyser Bight Geothermal area, Umnak Island, Aleutian Islands, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations RI 92-1, 85 p., 2 sheets, scale 1:24,000.

Nye, C.J., and Turner, D.L., 1990, Petrology, geochemistry, and age of the Spurr volcanic complex, eastern Aleutian Arc: Bulletin of Volcanology, v. 52, no. 3, p. 205–226.

Power, John, 2004, Renewed unrest at Mount Spurr Volcano, Alaska: Eos, v. 85, no. 43, p. 434.

Prejean, Stephanie, Moran, Seth, and Power, John, 2012, Volcanic earthquakes in Alaska’s National Parks, *in* Winfree, Robert (project lead), Katmai science studies: Alaska Park Science Journal, v. 11, no. 1, p. 40–45, http://www.nps.gov/akso/nature/science/ak_park_science/volume_11_issue_1.cfm.

Qu, Feifei, Lu, Zhong, Poland, Michael, Freymuller, Jeffrey, Zhang, Qin, and Jung, Hyung-Sup, 2015, Post-eruptive inflation of Okmok Volcano, Alaska, from InSAR, 2008–2014: Remote Sensing, v. 7, p. 16,778–16,794, doi:10.3390/rs71215839.

Reeder, J.W., 1990, Sugarloaf, *in* Annual report of the world volcanic eruptions in 1987: Bulletin of Volcanic Eruptions, v. 27, p. 36.

Richter, D.H., Waythomas, C.F., McGimsey, R.G., and Stelling, P.L., 1998, Geologic map of Akutan Island, Alaska: U.S. Geological Survey Open-File Report 98–0135, 22 p., 1 sheet, scale 1:48,000.

Riehle, J.R., 1985, A reconnaissance of the major Holocene tephra deposits in the upper Cook Inlet region, Alaska: Journal of Volcanology and Geothermal Research, v. 26, nos. 1–2, p. 37–74.

Roman, D.C., Power, J.A., Moran, S.C., Cashman, K.V., Doukas, M.P., Neal, C.A., and Gerlach, T.M., 2004, Evidence for dike emplacement beneath Iliamna Volcano, Alaska in 1996: Journal of Volcanology and Geothermal Research, v. 130, nos. 3–4, p. 265–284.

Schaefer, J.R., ed., 2011, The 2009 eruption of Redoubt Volcano, Alaska, with contributions by Bull, Katharine, Cameron, Cheryl, Coombs, Michelle, Diefenbach, Angie, Lopez, Taryn, McNutt, Steve, Neal, Christina, Payne, Allison, Power, John, Schneider, Dave, Scott, William, Snedigar, Seth, Thompson, Glenn, Wallace, Kristi, Waythomas, Chris, Webley, Peter, and Werner, Cynthia: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2011–5, 45 p., http://www.dggs.alaska.gov/pubs/id/23123.

Schaefer, J.R., Scott, W.E., Evans, W.C., Wang, Bronwen, and McGimsey, R.G., 2013, Summit crater lake observations, and the location, chemistry, and pH of water samples near Mount Chiginagak volcano, Alaska—2004–2012: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2011–6, v. 2, 25 p., http://www.dggs.alaska.gov/pubs/id/25602.

Siebert, L., Simkin, T., and Kimberly, P., 2010, Volcanoes of the world (3rd ed.): Berkeley, University of California Press, 568 p.

Waythomas, C.F., Dorava, J.M., Miller, T.P., Neal, C.A., and McGimsey, R.G., 1997, Preliminary volcano-hazard assessment for Redoubt Volcano, Alaska: U.S. Geological Survey Open-File Report 97–857, 40 p., 1 pl., scale unknown.

Waythomas, C.F., Power, J.A., Richter, D.H., and McGimsey, R.G., 1998, Preliminary volcano-hazard assessment for Akutan Volcano, east-central Aleutian Islands, Alaska: U.S. Geological Survey Open-File Report 98–360, 36 p., 1 pl., scale unknown.

Waythomas, C.F., and Miller, T.P., 1999, Preliminary volcano-hazard assessment for Iliamna Volcano, Alaska: U.S. Geological Survey Open-File Report 99–373, 31 p., 1 sheet, scale unknown.

Werner, C.A., Doukas, M.P., and Kelly, P.J., 2011, Gas emission from failed and actual eruptions from Cook Inlet volcanoes, Alaska, 1989–2006: Bulletin of Volcanology, v. 73, no. 2, p. 155–173, doi:10.1007/s00445-011-0453-4.

Glossary of Selected Terms and Acronyms

ADGGS Alaska Division of Geological & Geophysical Surveys.

AKDT "Alaska Daylight Time"; UTC -8 hours. Alaska Daylight time in 2013 ran from 10:00 UTC March 9 to 10:00 UTC November 2.

AKST "Alaska Standard Time"; UTC -9 hours.

andesite volcanic rock composed of about 53–63 percent silica (SiO2, an essential constituent of most minerals found in rocks).

ash fine fragments (less than 2 millimeters across) of lava or rock formed in an explosive volcanic eruption.

ASL above sea level.

AVHRR "Advanced Very High Resolution Radiometer"; AVHRR provides one form of satellite imagery.

AVO Alaska Volcano Observatory.

basalt general term for dark-colored igneous rock, usually extrusive, containing about 45–52 weight percent silica (SiO_2, an essential constituent of most minerals found in rocks).

bomb boulder-size chunk of partly solidified lava explosively ejected from a volcano.

breccia rock consisting of angular fragments cemented together.

caldera a large, roughly circular depression usually caused by volcanic collapse or explosion.

cinder cone small, steep-sided conical hill built mainly of cinder, spatter, and volcanic bombs.

FAA Federal Aviation Administration.

fallout a general term for debris that falls to the Earth from an eruption cloud.

fault a fracture along which the blocks of the Earth's crust on either side have moved relative to one another parallel to the fracture.

fissure a roughly linear or sinuous crack or opening on a volcano; a type of vent that commonly produces lava fountains and flows.

fumarole a small opening or vent from which hot gases are emitted.

GMT Greenwich Mean Time.

GPS Global Positioning System.

GVP Smithsonian Institution Global Volcanism Program.

Holocene geologic epoch extending from the present to 10,000 years ago.

IFM Islands of Four Mountains (including the volcanoes Tana, Cleveland, Herbert, and Carlisle).

infrasound low-frequency sound waves, below the threshold of human hearing.

InSAR Interferometric Synthetic Aperture Radar.

intracaldera refers to something within the caldera.

juvenile volcanic material created from magma reaching the surface.

KVERT Kamchatkan Volcanic Eruption Response Team.

lahar A flow of a mixture of pyroclastic material and water.

Landsat 8 an American earth observation satellite; the eighth in the Landsat program.

lava molten rock that has reached the Earth's surface.

Low-frequency earthquakes earthquakes with dominant frequencies between 1 and 5 Hz.

M an earthquake magnitude scale based on the amplitude of ground motion as measured by a standard seismograph.

magma molten rock below the surface of the Earth.

MODIS Satellite-based "Moderate Resolution Imaging Spectroradiometer."

Mogi model Calculated displacement field of a spherical pressure source buried in elastic halfspace, named after Mogi (1958).

NASA National Aeronautics and Space Administration.

NWS AAWU National Weather Service Alaska Aviation Weather Unit.

NOAA National Oceanic and Atmospheric Administration.

NWS National Weather Service.

OMI Ozone Mapping Instrument on NASA's Aura satellite.

phreatic activity an explosive eruption caused by the sudden heating of ground water as it comes in contact with hot volcanic rock or magma leading to a steam-driven explosion.

phreatic ash fine fragments of volcanic rock expelled during phreatic activity; this ash usually is derived from existing rock and not from new magma.

PIREP "Pilot Weather Report"; a report of meteorological phenomena encountered by aircraft in flight.

pixel contraction of "picture element." A pixel is one of the many discrete rectangular elements that form a digital image or picture on a computer monitor or stored in memory. In a satellite image, resolution describes the size of a pixel in relation to area covered on the ground. More pixels per unit area on the ground means a higher resolution.

pyroclast an individual particle ejected during a volcanic eruption; usually classified by size, for example, ash, lapilli.

RSAM Real-time Seismic Amplitude Measurement.

regional earthquake earthquake generated by fracture or slippage along a fault; not caused by volcanic activity.

satellite a subsidiary volcanic vent located on the flank of a larger volcano.

seismic swarm a flurry of closely spaced earthquakes or other ground shaking activity; often precedes an eruption.

SI International System of Units.

SIGMET SIGnificant METeorological information statement, issued by NWS.

Spatter cone a low, steep-sided cone of spatter built up on a fissure or vent.

Stratovolcano also called a stratocone or composite cone, a steep-sided volcano, usually conical in shape, built of interbedded lava flows and fragmental deposits from explosive eruptions.

Strombolian type of volcanic eruption characterized by intermittent bursts of fluid lava, usually basalt, from a vent or crater as gas bubbles rise through a conduit and burst at the surface.

SVA Suspect Volcanic Activity.

SVERT "Sakhalin Volcanic Eruption Response Team" monitors and reports on Kurile Island volcanoes.

SWIR Short Wave Infrared.

tephra a general term covering all fragmental material expelled from a volcano (ash, bombs, cinders, etc.).

tremor low-amplitude, continuous earthquake activity often associated with magma movement.

UAFGI University of Alaska Fairbanks Geophysical Institute.

USGS U.S. Geological Survey.

UTC "Coordinated Universal Time"; same as Greenwich Mean Time (GMT).

VAN Volcanic Activity Notice

vent an opening in the Earth's surface through which magma erupts or volcanic gasses are emitted.

VIIRS Visible Infrared Imaging Radiometer Suite.

volcano-tectonic earthquakes earthquakes generated within or near a volcano from brittle rock failure resulting from strain induced by volcanic processes.

VT volcano-tectonic earthquake.

WWLLN World Wide Lightning Location Network.

Appendix 1. Volcano Alert Levels and Aviation Color Codes Used by United States Volcano Observatories

Alert levels address the overall activity at the volcano, not just the hazard to aviation. There may be situations where a volcano is producing lava flows that are dangerous on the ground and merit a WATCH or WARNING, however, the hazard to aviation is minimal. Alert levels announcements contain additional explanation of volcanic activity and expected hazards where possible (Gardner and Guffanti, 2006).

Alert Levels	
NORMAL	Volcano is in typical background, noneruptive state. *Or, after a change from a higher level:* Volcanic activity has ceased and volcano reverted to its noneruptive state.
ADVISORY	Volcano is exhibiting signs of elevated unrest above known background level. *Or, after a change from a higher level:* Volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
WATCH	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain. *Or:* Eruption is underway but poses limited hazards.
WARNING	Highly hazardous eruption is imminent, underway, or suspected.

Level of Concern Codes for Aviation	
GREEN	Volcano is in typical background, noneruptive state. *Or, after a change from a higher level:* Volcanic activity has ceased and volcano has returned to noneruptive background state.
YELLOW	Volcano is exhibiting signs of elevated unrest above known background level. *Or, after a change from a higher level:* Volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain. *Or:* Eruption is underway with no or minor ash emissions [ash-plume height specified, if possible].
RED	Eruption is imminent with significant emission of volcanic ash into the atmosphere likely. *Or:* Eruption is underway or suspected with significant emission of volcanic ash into the atmosphere [ash-plume height specified, if possible].

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