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2012 Volcanic Activity in Alaska: Summary of Events and Response of the Alaska Volcano Observatory

Scientific Investigations Report 2014–5160

U.S. Department of the Interior
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Cover: Oblique aerial photograph of the southeastern flank of Kanaga Volcano, Kanaga Island, in the western Aleutians. Early in 2012, a new fissure opened across the summit, possibly during a short-lived phreatic eruption. In this image, minor steam still billows from the summit. Snow-capped Tanaga Island is in the distance. Photograph by C. Read, USGS/AVO, June 25, 2012. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=44071.

2012 Volcanic Activity in Alaska: Summary of Events and Response of the Alaska Volcano Observatory

By Julie A. Herrick, Christina A. Neal, Cheryl E. Cameron, James P. Dixon, and Robert G. McGimsey

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U.S. Department of the Interior
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Conversion Factors and Datum

Conversion Factors

Inch-Pound to SI

Multiply	By	To obtain
acre	4,047	square meter (m^2)
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)
ton per day (ton/d)	0.9072	metric ton per day

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

$$°C = (°F - 32) / 1.8$$

SI to Inch-Pound

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)
metric ton per day	1.1022	ton per day (ton/d)
millimeter (mm)	0.03937	inch (in)
square meter (m^2)	0.0002471	acre

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

$$°F = (1.8 \times °C) + 32.$$

Datum

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

2012 Volcanic Activity in Alaska: Summary of Events and Response of the Alaska Volcano Observatory

By Julie A. Herrick[1], Christina A. Neal[2], Cheryl E. Cameron[3], James P. Dixon[4], and Robert G. McGimsey[2]

Abstract

The Alaska Volcano Observatory (AVO) responded to eruptions, possible eruptions, volcanic unrest, or suspected unrest at 11 volcanic centers in Alaska during 2012. Of the two verified eruptions, one (Cleveland) was clearly magmatic and the other (Kanaga) was most likely a single phreatic explosion. Two other volcanoes had notable seismic swarms that probably were caused by magmatic intrusions (Iliamna and Little Sitkin). For each period of clear volcanic unrest, AVO staff increased monitoring vigilance as needed, reviewed eruptive histories of the volcanoes in question to help evaluate likely outcomes, and shared observations and interpretations with the public. 2012 also was the 100th anniversary of Alaska's Katmai-Novarupta eruption of 1912, the largest eruption on Earth in the 20th century and one of the most important volcanic eruptions in modern times. AVO marked this occasion with several public events.

Introduction

The Alaska Volcano Observatory (AVO) is responsible for monitoring the volcanoes of Alaska, warning those at risk, and conducting research to better understand how volcanoes work. As of December 31, 2012, 29 Alaskan volcanoes were instrumented with networks of seismometers sufficiently reliable in their operation to detect and track earthquake activity (fig. 1; table 1). Seismic data from these networks are reviewed daily. Seismic stations were installed at two additional volcanoes in 2005 (Little Sitkin and Semisopochnoi; fig. 1); however, telemetry links have remained intermittently operational and AVO does not consider these volcanoes to be seismically monitored. Wrangell's monitoring network suffered outages of such sufficient length that it was removed from the monitored list at the end of the year.

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Figure 1. Map showing 52 historically active volcanoes in Alaska along with 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 to be post-mid 1700s when written records of volcanic activity began. Map is modified from Schaefer and others (2014).

Table 1. History of seismic monitoring of Alaskan volcanoes from August 1971 through December 2012.

[History of seismic monitoring compiled by J. Dixon. “First station installed” refers to the date when AVO first received real-time data from the station. This date can be many months following initial fieldwork at the volcano. Alaska Volcano Observatory (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 six 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. 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)]

Volcano	Approximate start date of seismic monitoring	Magnitude of completeness
Wrangell	First station installed – July 2000 Network complete – **August 2001** Added to monitored list in weekly update – November 2001 Removed from list – January 27, 2012	0.9
Spurr	First station installed – August 1971 Network complete – **August 1989** Added to monitored list in weekly update – April 1991	0.2
Redoubt	First station installed – August 1971 Network complete – **August 1988** Added to monitored list in weekly update – April 1991	0.3
Iliamna	First station installed – September 1987 Network complete (Min 4 stations) – **September 1994** Added to monitored list in weekly update – April 1991	-0.4
Augustine	First station installed – October 1976 Network complete – **August 1978** Added to monitored list in weekly update – April 1991	0.0
Fourpeaked	First station installed – September 2006 Network complete (Min 4 stations) – **October 2006** Added to monitored list in weekly update – October 2006	0.4
Katmai-North (Snowy)	First station installed – August 1988 Network complete – **October 199**8 Added to monitored list in weekly update – December 1998	0.5
Katmai-Central (Griggs, Katmai, Novarupta, Trident)	First station installed – August 1988 Network complete (Min 4 stations) – **July 1991** Added to monitored list in weekly update – November 1996	0.5
Katmai-South (Martin, Mageik)	First station installed – August 1988 Network complete – **July 1996** Added to monitored list in weekly update – November 1996	0.5
Ukinrek Maars/ Peulik	First station installed – March 2005 Network complete (Min 4 stations) – **March 2005** Added to monitored list in weekly update – April 2005	0.3
Aniakchak	First station installed – July 1997 Network complete – **July 1997** Added to monitored list in weekly update – November 1997	1.4
Veniaminof	First station installed – February 2002 Network complete – **February 2002** Added to monitored list in weekly update – September 2002	1.3
Pavlof	First station installed – July 1996 Network complete – **July 1996** Added to monitored list in weekly update – November 1996	1.0

Table 1. History of seismic monitoring of Alaskan volcanoes from August 1971 through December 2012.—Continued

[History of seismic monitoring compiled by J. Dixon. "First station installed" refers to the date when AVO first received real-time data from the station. This date can be many months following initial fieldwork at the volcano. Alaska Volcano Observatory (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 six 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. 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)]

Volcano	Approximate start date of seismic monitoring	Magnitude of completeness
Dutton	First station installed – July 1988 Network complete – **July 1996** Added to monitored list in weekly update – November 1996	1.0
Shishaldin (and Isantoski)	First station installed – July 1997 Network complete – **July 1997** Shishaldin added to list in weekly update – November 1997 Isantoski added to list in weekly update – December 1998	0.6
Westdahl (and Fisher)	First station installed – August 1998 Network complete – **October 1998** Added to monitored list in weekly update – December 1998	1.1
Akutan	First station installed – March 1996 Network complete – **July 1996** Added to monitored list in weekly update – November 1996	0.3
Makushin	First station installed – July 1996 Network complete – **July 1996** Added to monitored list in weekly update – November 1996	0.7
Okmok	First station installed – January 2003 Network complete – **January 2003** Added to monitored list in weekly update – January 2004	0.9
Korovin	First station installed – July 2004 Network complete – **July 2004** Added to monitored list in weekly update – December 2005	0.7
Great Sitkin	First station installed – September 1999 Network complete – **September 1999** Added to monitored list in weekly update – December 1999	0.6
Kanaga	First station installed – September 1999 Network complete – **September 1999** Added to monitored list in weekly update – December 2000	1.2
Tanaga	First station installed – August 2003 Network complete – **August 2003** Added to monitored list in weekly update – June 2004	1.3
Gareloi	First station installed – August 2003 Network complete – **September 2003** Added to monitored list in weekly update – June 2004	1.2
Semisopochnoi (Cerberus)	First station installed – September 2005 Network complete – **September 2005** Added to monitored list in weekly update – not yet added	1.0
Little Sitkin	First station installed – September 2005 Network complete – **September 2005** Added to monitored list in weekly update – not yet added	0.0

AVO's volcano monitoring program also includes daily analysis of satellite and Web camera images, occasional overflights, airborne-gas measurements, compilation of pilot reports (PIREPS), and observations by local residents and mariners. AVO receives real-time deformation data from permanent Global Positioning System (GPS) stations at four Alaskan volcanoes (Okmok, Augustine, Akutan, and Mount Spurr). Periodic analysis of Interferometric Synthetic Aperture Radar (InSAR) images is used to detect deformation at volcanoes in Alaska (for example, Lu, 2007). AVO also is increasing the use of infrasound sensors and ground coupled airwaves recorded on seismometers to detect explosions throughout the Aleutian arc (for example, Fee and others, 2010; De Angelis and others, 2012).

This report summarizes notable volcanic activity in Alaska during 2012 and briefly describes AVO's response. We include information on all volcanoes at elevated alert status and those that prompted increased attention by AVO staff, even if no formal public notification ensued. We also include selected observations, images, and data that are difficult to publish elsewhere due to their limited scope and transience. This summary complements the annual AVO seismic catalogs that detail earthquake monitoring results for all Alaskan volcanoes on an annual basis (for example, Dixon and others, 2011).

As part of AVO's longstanding close cooperation with Russian volcano monitoring and reporting groups in the Russian Far East (Neal and others, 2009a), earlier versions in this report series included summaries of activity in Kamchatka and the Kurile Islands (table 4c). Beginning with the 2011 report (McGimsey and others, 2014), AVO no longer includes this information and instead refers readers to the Web sites of the Kamchatka and Sakhalin Volcanic Eruption Response Teams (http://www.kscnet.ru/ivs/kvert/index_eng.php and http://www.imgg.ru/?id_d=659) and to the Web site of the Smithsonian Institution's Global Volcanism Program (GVP; http://www.volcano.si.edu/).

Information is presented in geographic order from northeast to southwest along the Aleutian Arc. For each entry, a title block contains the volcano's unique identifier assigned by the GVP, the volcano's latitude and longitude, summit elevation, and region of occurrence. Each event summary ends with a brief paragraph of background comments about the volcano. (Note we are including in this report both the GVP legacy volcano number and a new unique number assigned during the GVP database redesign in 2013.) Information is derived from published material as well as AVO daily status reports, weekly updates and special information releases, AVO email and online electronic logs, and the Smithsonian Institution Global Volcanism Network Bulletins that are available at URL: http://www.volcano.si.edu/reports_bgvn.cfm.

Table 1 is a history of seismic monitoring of Alaskan volcanoes from August 1971 through December 2012. Table 2 summarizes 2012 volcanic activity in Alaska. Table 3 lists changes in Aviation Color Codes in 2012 for Alaskan volcanoes. Descriptions of Aviation Color Codes and Volcano Alert Levels used in Alaska are presented in appendix 1. Tables 4a, 4b, and 4c present cross-referenced lists of volcanic activity by year and by volcano for this and all previous AVO annual activity reports. All AVO Annual Summary reports also are available at URL: http://www.avo.alaska.edu/downloads/classresults.php?pregen=annsum.

Altitudes and elevations reported are in feet or meters above sea level (ASL) unless noted otherwise. Time is reported as Alaska Standard Time (AKST) or Alaska Daylight Time (AKDT), as needed. For most satellite or geophysical instrumentation references, times are given in Coordinated Universal Time (UTC). We preserve English or Inch-Pound units of measurement especially where they reflect the primary observations of distance or altitude such as those commonly received via pilot reports and aviation authorities in the United States. Elsewhere, measurements are presented in International System of Units (SI) with approximate conversions to Inch-Pound Units in parentheses for convenience. 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 (WGS 1984 datum) and may differ slightly from previous compilations and from the Smithsonian Institution's Smithsonian Global Volcanism Program's Volcanoes of the World database.

Table 2. Summary of 2012 volcanic activity in Alaska, including actual eruptions, possible eruptions, unusual increases in seismicity or fumarolic activity.

[Location of volcanoes shown in figure 1]

Volcano	Date of activity	Type of activity
Wrangell Volcano	March and June	Citizen observations of fumarolic plumes.
Spurr Volcano	June 25, 2012	Glacial outburst flood.
Redoubt Volcano	Throughout the year	Degassing, robust fumarolic plumes.
Iliamna Volcano	Throughout the year	Seismic swarms, avalanches from east face.
Augustine Volcano	March, June, August	Fumarolic plumes, brief bursts of seismicity, sulfur odor.
Fourpeaked Volcano	August through years' end	Increased seismicity.
Martin Volcano	Intermittent throughout year	Elevated seismicity, vapor/volcanic gas plumes.
Aniakchak Volcano	Intermittent throughout year	Increased seismicity, possible tremor.
Cleveland Volcano	Intermittent throughout year	Lava extrusion, explosions, small ash clouds.
Kanaga Volcano	February 18, 2012	Phreatic (?) explosion, limited ash fall, steaming new fissure across summit.
Little Sitkin Volcano	August through year's end	Seismic swarms, likely magmatic intrusion

Table 3. Alaskan volcanoes with Aviation Color Code and Volcano Alert Level changes in 2012.

[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 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
WRANGELL	
GREEN/NORMAL	January 1 – January 27
UNASSIGNED	January 27 – December 31
ILIAMNA	
GREEN/NORMAL	January 1 – March 9
YELLOW/ADVISORY	March 9 – December 31
CLEVELAND	
YELLOW/ADVISORY	January 1 – January 31
ORANGE/WATCH	January 31 – March 23
YELLOW/ADVISORY	March 23 – March 28
ORANGE/WATCH	March 28 – May 30
YELLOW/ADVISORY	May 30 – June 19
ORANGE/WATCH	June 19 – September 5
YELLOW/ADVISORY	September 5 – November 10
ORANGE/WATCH	November 10 – November 21
YELLOW/ADVISORY	November 21 – December 31

Color Code	Date of change
KANAGA	
GREEN/NORMAL	January 1 – February 18
YELLOW/ADVISORY	February 18 – March 2
GREEN/NORMAL	March 2 – December 31
LITTLE SITKIN	
UNASSIGNED	January 1 – August 30
YELLOW/ADVISORY	August 30 – December 31

Table 4a. Compilation by year of volcanoes included in an Alaska Volcano Observatory Annual Summary, 1992–2012.

[Volcanoes are presented in geographical order from northeast to southwest along the Wrangell-Aleutian volcanic arc and north to south along Kamchatka and the Kurile Islands. Prior to 1995 and after 2010, Alaska Volcano Observatory did not report on Russian volcanoes]

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, Mount Katmai)	Karymsky
Pavlof	Avachinsky
Shishaldin	Mutnovsky
Westdahl	Alaid (Kurile Islands)
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
Pavlof	Klyuchevskoy
Frosty	Bezymianny
Shishaldin	Karymsky
Makushin	Avachinsky
Okmok	
Cleveland	
Great Sitkin	

Table 4a. Compilation by year of volcanoes included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[Volcanoes are presented in geographical order from northeast to southwest along the Wrangell-Aleutian volcanic arc and north to south along Kamchatka and the Kurile Islands. Prior to 1995 and after 2010, Alaska Volcano Observatory did not report on Russian volcanoes]

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

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

Table 4a. Compilation by year of volcanoes included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[Volcanoes are presented in geographical order from northeast to southwest along the Wrangell-Aleutian volcanic arc and north to south along Kamchatka and the Kurile Islands. Prior to 1995 and after 2010, Alaska Volcano Observatory did not report on Russian volcanoes]

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

Table 4b. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2012.

[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
		Alaska (east to west)
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	Anamalous clouds
Sanford	1993	SVA, reported steam plume likely from avalanche
	1994	SVA, reported steam plume likely from avalanche
	1997	SVA, large steam cloud from SW face
	2009	Persistent anomalous clouds
	2010	Anomalous cloud from SW 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
Redoubt	1992	SVA, steam plume from still-cooling dome
	2003	SVA, anomalous weather cloud
	2007	Possible steaming and increased thermal flux
	2008	Pre-eruption increase in gas emissions and thermal flux from summit crater
	2009	Major magmatic eruption, domes, lahars, ash fall
	2010	Vapor and gas clouds; brief uptick in seismicity
	2012	Degassing, robust 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
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 4b. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[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
	Alaska (east to west)—Continued	
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
Katmai Group		
Mageik	1992	SVA, anomalous cloud
Martin/Mageik/Trident	1994	SVA, plume-like cloud
Martin	1995	SVA, large steam plume
Martin/Mageik/Trident/Mount 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
	2006	Earthquake swarm
	2010	Re-suspended ash
	2012	Elevated seismicity, fumarolic plumes
Martin/Mageik/Trident	2005	SVA, steam cloud, re-suspended ash, new crater?
Becharof Lake	1998	SVA, intense seismic swarm and inflationary episode
	2010	Earthquake swarm
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
Aniakchak	2005	SVA, anomalous seismicity, thermal anomaly
	2008	Weather related noise on seismic stations
	2009	Anomalous seismicity
	2010	Low frequency earthquake swarm
	2011	Anomalous seismicity
	2012	Increased seismicity, possible tremor
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
	2010	Sporadic seismicity, vapor plumes
Kupreanof	1994	SVA, PIREP of unusual steam plume

Table 4b. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[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
Alaska (east to west)—Continued		
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
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
	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 plumes, thermal anomalies
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
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
Bogoslof	1992	Dome extrusion, ash and steam emissions
Okmok	1997	Strombolian eruption
	2001	SVA, seismic swarm
	2008	Major Phreatomagmatic eruption
	2009	Caldera floor uplift, tremor burst
	2011	Inflation
Vsevidof	1999	SVA, sighting of ash after regional earthquake

Table 4b. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[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
	Alaska (east to west)—Continued	
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
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
Kliuchef (Atka)	1993	SVA, audible rumbling, strong sulfur odor
	1995	SVA, large steam plume, strong sulfur odor
Korovin (Atka)	1996	SVA, PIREP of ash cloud, suspicious cloud on satellite image
	1998	Eruption; explosions and ash fall
	2005	Minor eruption, steam and ash
	2006	Seismic swarms, uplift, increased fumarolic activity
	2007	Seismic swarms; fumarolic activity
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
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
Tanaga	2005	SVA, anomalous seismicity, including a period of tremor
Little Sitkin	2012	Seismic swarms, likely magmatic intrusion

Table 4b. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[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
Kamchatka and northern Kurile Islands (north to south) — activity through 2010		
Sheveluch	1997	Dome extrusion
	1998	Lava dome growth
	1999	Lava dome growth and collapse, ash
	2000	Lava dome growth, ash
	2001	Lava dome growth and collapse, ash
	2002	Lava dome growth, ash, pyroclastic flows
	2003	Lava dome growth, ash, pyroclastic flows, lahar
	2004	Lava dome growth, pyroclastic flows, lahars, ash
	2005	Lava dome growth, dome collapse, pyroclastic flows, ash
	2006	Lava dome growth, dome collapse, explosions
	2007	Lava dome growth, dome collapse, explosions
	2008	Lava dome growth, dome collapse, explosions
	2009	Lava dome growth, dome collapse, explosions
	2010	Lava dome growth, dome collapse, explosions
Klyuchevskoy	1996	Gas/ash eruption
	1997	Gas/ash eruption
	1998	Gas/ash eruption
	1999	Gas/ash eruption
	2000	Vulcanian explosions
	2001	Fumarolic plume
	2002	Elevated seismicity, gas-rich explosion
	2003	Elevated seismicity, ash explosion, Strombolian activity
	2004	Elevated seismicity
	2005	Strombolian eruption, lava flows, lahars
	2006	Increased seismicity, thermal anomaly, no eruption
	2007	Ash emission, Strombolian lava fountaining, lava flows
	2008	Strombolian lava fountaining, lava flows, lahars, phreatic explosions
	2009	Strombolian, Vulcanian activity, lava flow production, ash falls
	2010	Strombolian lava fountaining, explosions, lava flows, lahars
Bezymianny	1995	Explosive eruption
	1996	Lava extrusion
	1997	Dome collapse and explosive eruption
	1998	Degassing and spalling of new dome
	1999	Degassing and spalling of new dome, ash
	2000	Dome growth, explosive eruption
	2001	Accelerated dome growth, pyroclastic flows
	2002	Accelerated dome growth, explosions, pyroclastic flows
	2003	Dome growth and explosive collapse
	2004	Minor explosive eruptions, gas and steam emissions
	2005	Dome growth continues, two explosive episodes
	2006	Dome growth continues, two explosive episodes
	2007	Dome growth continues, pyroclastic avalanches, ash clouds
	2008	Dome growth continues, ash explosion
	2009	Dome growth continues
	2010	Dome growth continues, ash explosion

Table 4b. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary, 1992–2012.—Continued

[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
Kamchatka and northern Kurile Islands (north to south)— activity through 2010—Continued		
Karymsky	1995	Increased seismicity
	1996	Explosive eruption
	1997	Low level Strombolian eruptions
	1998	Low level Strombolian eruptions
	1999	Low level Vulcanian and Strombolian eruptions
	2000	Low level Vulcanian and Strombolian eruptions
	2001	Low level Vulcanian and Strombolian eruptions
	2002	Low level Vulcanian and Strombolian eruptions, explosions, avalanches
	2003	Vulcanian and Strombolian eruptions intensify
	2004	Low level Vulcanian and Strombolian eruptions
	2005	Low level Vulcanian and Strombolian eruptions, explosions, lava, ash fall
	2006	Low level Vulcanian and Strombolian eruptions
	2007	Low level Vulcanian and Strombolian eruptions
	2008	Low level Vulcanian and Strombolian activity
	2009	Low level Vulcanian and Strombolian activity
	2010	Low level Vulcanian and Strombolian activity
Koryaksky	2008	Phreatic explosions and ash emission
Avachinsky	1996	Increased seismicity
	2001	Increased seismicity, phreatic explosion
	2005	Increased seismicity, thermal anomalies
Mutnovsky	1996	Fumarolic plume
	2000	Gas and steam explosion
	2005	Increased fumarolic activity
	2007	Increased seismicity; uncertain source
	2008	Increased seismicity; uncertain source and fumarolic activity at Gorely
Gorley	2007	Increased seismicity; uncertain source
	2008	Increased seismicity; uncertain source and fumarolic activity at Gorely
	2009	
	2010	Increased seismicity, thermal output, degassing
Alaid (Kurile Islands)	1996	Ash plume
	1997	SVA
Ebeko	2005	Increased fumarolic activity and phreatic eruptions
	2006	Increased fumarolic activity
Chikurachki	2003	Stombolian and Vulcanian eruption, ash fall
	2005	Brief explosion produces ash and ash fall
	2007	Ash explosions
	2008	Explosions and limited ash clouds
Severgin	2006	Phreatic or fumarolic activity
Sarychev	2009	Major magmatic eruption; check location in table
Chirinkotan	2004	Brief, low-level steam, gas, and ash emission
Ekarma	2010	Phreatic eruption, lahar detected after the fact; sheck location in table
Berga	2006	Phreatic or fumarolic activity
	2007	Possible phreatic or fumarolic activity
Tyatya	2008	Possible increase in fumarolic activity

Table 4c. Citations for Alaska Volcano Observatory Annual Summary reports, 1992–2012.

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/usgspubs/ofr/ofr9583
1993	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 96-24, 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, 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.	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 OF 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, 57 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/
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/

Table 4c. Citations for Alaska Volcano Observatory Annual Summary reports, 1992–2012.

Year	Citation	URL
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, 87 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., Chibisova, M., Rybin, A., McGimsey, R., and Dixon, J., 2013, 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 2013-5034, 76 p.	http://pubs.usgs.gov/sir/2013/5034/
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, Dixon, and McGimsey 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/

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. Other definitions restrict eruptions to magmatic events, but the fragmental material ejected may be old as well as new. The explosive interaction of volcanically generated heat and near-surface water can cause dramatic eruptions without any fresh volcanic material reaching the surface and, from a volcanic hazards perspective, can be as important to document as magmatic events..." (http://www.volcano.si.edu/faq.cfm#q2). 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 an "historically active volcano"?

AVO defines an "active" volcano as a volcanic center that has had a recent eruption (see above) or period of intense deformation, seismic or fumarolic activity that is inferred to reflect the presence of magma at shallow levels within the volcano. The "historic" period in Alaska is now considered to be post-mid-1700s 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 Alaskan volcanoes fit these criteria. This is a change from 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. A recent eruption highlights this situation: Fourpeaked Mountain, once thought not to have erupted in the Holocene, produced a phreatic eruption in the fall of 2006. It now ranks as an historically active volcano, despite not appearing on the list prior to 2006. The AVO annual summary often contains information about reports of unusual activity at volcanoes that are not considered "historically active." Some examples are often non-volcanic in nature. Determining the significance of these observations is a responsibility of AVO and thus, they are included in this report.

Volcanic Activity in Alaska, Northeast to Southwest along Aleutian Arc

Wrangell Volcano

GVP New # 315020

CAVW# 1105-02-

62°00'N 144°01'W
4,317 m (14,163 ft)

Copper River Basin

NUMEROUS PLUME REPORTS

No eruptive activity or significant unrest occurred at Wrangell in 2012, but, as in previous years, AVO received reports of fumarolic activity located high on the flanks of this large, ice-covered volcano. Due to seismic station outages, Wrangell was removed from the monitored list on January 27 where it remained for the rest of the year. At the same time, following formal protocols, the Aviation Color Code and Volcano Alert Level at Wrangell were downgraded from **GREEN/NORMAL** to **UNASSIGNED** (appendix 1).

On March 11, observers in Glennallen noted "puffs of steam" and called the State of Alaska Department of Homeland Security and Emergency Management office with their concerns. AVO was also contacted and analysts were able to see small plumes above known fumaroles in satellite images.

On March 20, a citizen noticed unusually vigorous steaming at Wrangell while driving towards the volcano from Valdez. Steam rose from the summit as well as a location on the southwestern flank at about 3,000 m (10,000 ft) ASL and the citizen described the volcano as looking like "a pressure cooker shot through with nails" (fig. 2). There also were calls to the observatory on June 21 due to concerns about substantial plumes visible from various vantage points in the Copper River basin. No other evidence of significant volcanic unrest was detected, thus AVO concluded these events were likely generated by normal fumarolic activity. No further response activities were required.

Mount Wrangell is a massive, glacier-covered volcano in the Wrangell-St. Elias National Park and Preserve of eastern Alaska (fig. 1; Richter and others, 1995). Geothermally active areas occur on the eastern and western rims of the ice-filled 4 × 6 km (2.5 × 3.7 mi) summit crater, historically the source of nearly constant fumarolic emission (Benson and others, 2007). Resultant vapor plumes can be quite vigorous and sometimes reach hundreds of meters (thousands of feet) above ground level, occasionally entraining fine fragmental debris and producing localized deposits of dark material on the ice. This, in addition to wind redistribution of debris from the summit area, is often mistaken for eruptive activity. A four-station seismic network is frequently out of service due to harsh winter conditions. AVO relies on local observers, pilots, and satellite images to report activity at the volcano. Except for a vigorous steam and occasional phreatic ash emission, no historical magmatic eruptions are known to have occurred (Richter and others, 1995). A 'lava flow' eruption reported in 1902 (Mendenhall, 1905) is considered an unconfirmed eruption report.

Figure 2. Mount Wrangell as viewed from near Glennallen, Alaska, March 20, 2012. Note white water vapor plumes rising from known fumaroles high on the flank of Wrangell and from within the summit crater. Photograph by Mike Case, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=42211.

Mount Spurr Volcano

GVP New # 313040

CAVW# 1103-04-

61°18'N 152°15'W
3,374 m (11,070 ft)

Cook Inlet

SEISMICITY ABOVE BACKGROUND; GLACIAL OUTBURST

During 2012, the Aviation Color Code and Volcano Alert Level for Mount Spurr remained **GREEN/NORMAL** throughout the year, despite periods of anomalous seismicity and a glacial outburst flood that prompted closer evaluation by AVO staff.

In January, the number of located earthquakes beneath Mount Spurr increased over background. By January 30, the rate of small events was 1–3 per hour, increasing to 2–4 events per hour on January 31. Seismicity remained slightly elevated into early February (up to 2–6 events per hour) but abated by February 12. AVO seismologists attributed the swarm to deformation within glaciers covering the edifice triggered by unseasonably warm weather. Several deep, low frequency events also occurred in February and March, but this was not considered a significant departure from background.

On May 15, a pilot familiar with the volcano reported sulfur odors, likely hydrogen sulfide, during an overflight of the Mount Spurr area. He noted typical fumarolic activity on the summit cone, describing white plumes rising vertically in calm wind conditions. Some yellow-tinged (sulfur) snow was visible, but otherwise, the pilot reported no significant changes in the summit region. Snow continued to slowly infill the southern portion of the 2004 summit melt cauldron (Coombs and others, 2006) compared to previous views (fig. 3). An airborne gas measurement flight to Mount Spurr on June 22 took advantage of clear conditions to photograph the summit area (fig. 3). White vapor plumes rose from the long-lived fumarolic vents within the summit crater. Sulfur-dioxide (SO_2) flux was low, but flying conditions were difficult and the aircraft may have been unable to travel completely below the plume (C. Werner, USGS, written commun., 2012)

On June 25, a glacial outburst flood was recorded on seismograph station CKN located downstream of the Kidazgeni Glacier that flows from the Mount Spurr summit icefield and around the eastern flank of Crater Peak. Based on the duration of seismicity, the event lasted at least 45 minutes. Later observations indicated that water had escaped from beneath the Kidazgeni Glacier, flowing downstream and into the Chakachatna River that drains into Cook Inlet. By June 27, seismicity related to the outburst flood and response of the glacier had ended. The seismic record of this event was similar to that observed during another Kidazgeni outburst flood in 1993 (Nye and others, 1995).

On October 17, a pilot contacted AVO to report visible vapor emissions from the summit area of Mount Spurr. After AVO staff reviewed available satellite images, the local Web camera, and seismic data, it was determined that no significant change had occurred. Slightly elevated surface temperatures were detected at Mount Spurr in satellite images on October 18 and 23, however, they were not considered significant departures from background.

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 Mount Spurr's summit (Keith, 1995 and references therein). Each of these eruptive phases produced ash falls on populated areas of south-central Alaska. The summit of Mount Spurr is a largely ice-covered feature previously interpreted as a lava dome complex (Nye and Turner, 1990). The last known significant eruption based on correlation of tephra deposits was about 5,200 years ago (Riehle, 1985). In 2004, seismicity, surface heat flux, and gas emissions suggested a magmatic intrusion (Power, 2004; Neal and others, 2005; Coombs and others, 2006).

Figure 3. Oblique aerial view of the summit area of Mount Spurr as seen from the north. The summit peak reaches an elevation of about 3,374 m (11,070 ft) ASL. The circular depression, about 200 m (660 ft) in diameter, formed between 2004 and 2006 in response to the melting of ice related to an intrusion beneath the summit (Power and others, 2004; Coombs and others, 2006). Bare rock is visible on the northern and western inner walls of the crater. Circle indicates location of strong, jetting fumaroles that emit measureable volcanic gas. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=43211.

Redoubt Volcano

GVP New # 313030

CAVW# 1103-03-

60°29'N 152°45'W
3,108 m (10,197 ft)

Cook Inlet

COOLING 2009 LAVA DOME; CONTINUED DEGASSING, PLUME REPORTS

During 2012, the Aviation Color Code and Volcano Alert Level at Redoubt remained **GREEN/NORMAL**. Activity related to cooling and continued degassing of the 2009 lava dome sparked citizen attention on clear days prompting emails and telephone calls to AVO.

Multiple pilots filed reports through air traffic control describing towering vapor plumes (and occasional sulfur odors) throughout the year (fig. 4). On September 1 and 2, the summit plume was significant enough to stop automobile traffic on the Sterling Highway, according to a call received by the AVO duty scientist. Elevated surface temperatures in satellite images of Redoubt were not considered a significant departure from expected thermal signatures of a cooling lava dome. Seismicity remained at low levels even during times of significantly large fumarolic plumes.

During an AVO gas measurement flight on March 17, the crew noted sulfur odors downwind of Redoubt en route to Iliamna. SO_2 flux measured during flights in late March and June was low and about what was expected several years after cessation of lava effusion. The 2009 lava dome remained mostly snow-free in 2012; continued degassing through the rubbly carapace produced dramatic clouds under the right atmospheric conditions (figs. 5 and 6).

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. Recent eruptions occurred in 1902, 1966–68, 1989–90, and 2009 (Waythomas and others, 1997; Schaefer, 2011). The 1989–90 and 2009 eruptions produced mudflows, or lahars, that traveled down the Drift River and partially flooded the Drift River Oil Terminal facility. The 1966–68 eruption also produced lahars down the Drift River. Ash clouds produced by the 1989–90 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 4. Redoubt Volcano and plume from the cooling 2009 lava dome as seen from the Soldotna area on the Kenai Peninsula (fig. 1), October 13, 2012. Photograph by Michael Gravier, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=46901.

Figure 5. Aerial view towards the south of the summit of Redoubt Volcano, the dark rubbly 2009 lava dome, and a hazy plume of volcanic gas emanating from the dome. On this day, low wind speeds led to accumulation of volcanic gas in and around the summit crater area, making gas measurements difficult. Photograph by Christopher Kern, USGS/CVO, June 22, 2012. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=43291.

Figure 6. Aerial view of 2009 lava dome that occupies the north-facing crater of Redoubt Volcano. Multiple sources of water vapor and volcanic gas plumes are visible on the surface of the dome. Photograph by Game McGimsey, USGS/AVO, August 13, 2012. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=46551.

Iliamna Volcano

GVP New # 313020

CAVW# 1103-02-

60°02'N 153°04'W
3,053 m (10,017 ft)

Cook Inlet

SEISMIC SWARMS, AVALANCHE ACTIVITY

Iliamna Volcano was restless in 2012, prompting increased monitoring vigilance and a Volcano Alert Level upgrade. Two avalanches, one minor event in late January, and a significant collapse in July modified the upper region of Red Glacier on the eastern flank of Iliamna. Elevated seismicity persisted throughout the year with notable peaks in late January and February. Gas measurement flights on March 17, June 20, and August 13 determined that emissions were above background and similar to levels last detected during the intrusion and 'failed eruption' of 1996 (Roman and others, 2004; Werner and others, 2011). Elevated surface temperatures in the summit area detected in satellite images were rare and often attributed to solar reflection. A new Web camera installed in mid-March aided remote observations of fumarolic activity.

From January 15 through 17, AVO detected a swarm of volcanic-tectonic (VT) events with the largest event in the sequence being an M2.7 earthquake on January 17; subsequent analysis (H. Buurman, UAFGI, written commun., 2014) places the beginning of the swarm as early as December 22, 2011. On January 27, a pilot called AVO to inquire about webicorder signals displayed on AEC (Alaska Earthquake Center, formerly AEIC, the Alaska Earthquake Information Center) and AVO Web sites. Anticipating additional questions about elevated seismicity at Iliamna, AVO posted explanatory information on the public-access webicorder plot.

On March 7, AVO received a telephone call from Dennis Anderson, a photographer from Diamond Ridge above Homer, Alaska. Anderson reported observations of avalanche activity and appearance of new crevasses on the Red Glacier of Iliamna (fig. 7). Public attention resulted in local media calls to AVO and several news stories on the avalanche and increase in seismicity. On March 8, the largest events of the unrest sequence were recorded (M2.96 and M3.01). On March 9, based on the sustained increase in seismicity, AVO upgraded the Aviation Color Code and Volcano Alert Level for Iliamna to **YELLOW/ADVISORY**. Following the upgrade of Color Code and Alert Level, AVO increased the frequency of seismic checks to once every 6 hours.

Examination of photographs from Anderson and satellite images from early March showed clear evidence of avalanching of debris on the upper Red Glacier. Photographs from March 12 showed a vapor plume, 2–4 km (1–2.5 mi) above the crater, drifting north from the summit area. AVO received no reports of increased or anomalous sulfur smell.

On March 14, a fumarolic plume was visible on satellite images that drifted north-northwest from the summit; the length and prominence of this cloud-feature was unusual for Iliamna. Based on the appearance of this plume in mid-infrared images, it is possible that the feature was a predominantly water-rich meteorological cloud influenced by a strong Iliamna fumarolic plume.

In mid-March, a Web camera (*AnnaCam*) managed by Hilcorp on a platform in the middle of Cook Inlet was repositioned to allow for visibility of both Iliamna and Redoubt within the same field of view. At the same time, AVO installed a new Web camera pointed at Iliamna (station NNL) on the Kenai Peninsula.

AVO seismologists determined that the 2012 earthquake sequence was occurring just south of the summit at 0–4 km (1–2.5 mi) depth. The swarm appeared similar to activity in 1996 (Roman and others, 2004), although the 2012 swarm also had low frequency earthquakes, which were not present in 1996 (H. Buurman, UAFGI, written commun., 2014).

A gas measurement flight to Iliamna on March 17 noted levels of carbon-dioxide (CO_2) and SO_2 at similar values as in 1996 (C. Werner, USGS, written commun., 2012). AVO observers on this flight noted visibly disturbed ice in the area of the upper Red Glacier. Close-up views of the main fumarolic field revealed robust steam- and gas-plumes with possible jetting from some sources (figs. 8 and 9). The high southern flank fumarolic field also was more active than usual. Several possible new vents were noted high on the eastern flank that later in the year appeared less active. Minor, recent icefalls also were noted on the western flank.

Figure 7. Views of the eastern flank of Iliamna Volcano from Homer, Alaska, July 12, 2011 (left) and March 9, 2012 (right) showing changes in the Red Glacier. Annotation by Max Kauffman, AVO/UAFGI. Photographs by Dennis Anderson, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php?id=42111.

Figure 8. View of the summit area of Iliamna, March 17, 2012. Photograph by Game McGimsey, USGS/AVO. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=42201.

Figure 9. View of the summit area of Iliamna comparing fumarolic activity in March and August 2012. Photographs and annotation by Game McGimsey, USGS/AVO from March 17 (bottom) and August 13 (top), 2012. Circles highlight observed point sources of fumarolic emission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=46601.

Observations from the gas flight verified that the upper Red Glacier descending Iliamna's eastern flank had undergone a surge in early 2012. This fast creep (or slow slide) event was not a true avalanche, but it was sourced in the same area as large avalanches of the recent past (Huggel and others, 2007). At the time of the observations, it was unclear if the surge was related to changes in the volcano, such as the increase in seismicity, associated increases in heat and gas flux, or just a result of heavy snowfall during the winter of 2011–2012.

Into late March, distinctive plumes continued to appear in mid-infrared satellite images. On March 21, sulfur odors were reported by a pilot about 24 km (15 mi) west of Iliamna. Web camera images showed occasional plumes from the summit fumarole fields and above background seismicity persisted through the year's end. Possible thermal anomalies in satellite images were detected on a number of occasions during the year; it remains uncertain if these were a clear departure from background thermal conditions.

A second gas flight to Iliamna on June 20 (fig. 10) measured SO_2, hydrogen sulfide (H_2S), and CO_2 emissions similar to the March 17 flight when measurements were considered elevated over background and were comparable to the highest measurements from the episode of unrest in 1996. A third flight on August 13 determined that volcanic gas emission continued at elevated levels. Less robust visible vapor plumes suggested a possible decrease in activity, but relatively dry and warm atmospheric conditions may have played a role in the apparent change.

On August 21, a citizen called AVO to report a plume rising from Iliamna. Conditions were clear that day and the mountain was backlit. The observer called it an "uncommon plume" that billowed from the summit with more vigor than typically noted. Later that month (August 27), another observer noted a sulfur odor at Anchor Point on the Kenai Peninsula (fig. 1). Back trajectories from a HYSPLIT model indicated that a gaseous plume from Iliamna would have drifted over Anchor Point at that time, suggesting Iliamna was a likely source. Problems with the seismic network led to data drops and challenges in tracking seismicity in the late summer. When data flow resumed in late September and AVO determined that elevated seismicity at Iliamna had continued.

A photograph was taken by a resident on October 13 that showed a flow feature on the southeastern flank of Iliamna (fig. 11). A review of seismic records showed that a possible landslide signal had been recorded at 8:16 p.m. AKDT on October 12 (04:16 UTC October 1), consistent with the apparent flowage deposit captured in the photograph. The dimensions of the avalanche were determined on October 22 with the help of satellite images. At the widest part, the feature was 2,800 × 200 m (1.7 × 0.1 mi). The landslide had originated near the existing fumarolic area high on the southeastern flank just below the summit. Some small melt slides had been visible in that area several days earlier.

Elevated seismicity continued through October and November with hypocenters roughly coincident with the 1996 activity. Two bursts of low-frequency seismicity occurred on November 24. Based on the continued levels of seismicity, AVO maintained Aviation Color Code and Volcano Alert Level **YELLOW/ADVISORY** into 2013. Seismicity and gas measurements during the 2012 unrest are likely explained by a magmatic intrusion to shallow levels below the volcano (Prejean and others, 2012.)

Iliamna Volcano is a little-known, glaciated stratovolcano located approximately 215 km (134 mi) southwest of Anchorage on the western side of the 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 2,740 m (8,990 ft) ASL on the eastern flank produce nearly constant plumes of steam condensate and volcanic gas (Werner and others, 2011).

Figure 10. View of the summit area of Iliamna, June 22, 2012. Photograph by Game McGimsey, USGS/AVO. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=43261.

Figure 11. View from Homer, Alaska, of Iliamna and avalanche formed in mid-October (circled). Photograph by Dennis Anderson, October 13, 2012, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=46861.

Augustine Volcano

GVP New # 313010

CAVW# 1103-01-

59°22'N 153°26'W
3,053 m (10,017 ft)

Cook Inlet

VAPOR PLUMES, TREMOR, SULFUR ODORS

Very minor unrest occurred at Augustine Volcano in 2012 in the form of visible vapor plumes, slightly elevated seismicity, and continued low-level degassing from the summit. The Aviation Color Code and Volcano Alert Level at Augustine remained **GREEN/NORMAL** throughout the year.

Intermittent bursts of seismicity occurred throughout the year and tremor-like events were noted during March 22 through 23. Similar tremor events occurred again in June and the source process remains indeterminate.

During a gas flight on June 20 with clear weather conditions, a distinct white plume rose from the still-cooling 2006 lava dome at the volcano's summit (fig. 12). Volcanic gases were still present at expected levels 6 years after the end of the 2006 eruption.

On August 24, AVO received an email alert from Anchor Point, Alaska that reported a sulfur odor that evening (8:00–9:00 p.m. AKDT; 04:00–05:00 UTC August 25) similar to what they had noticed during Augustine's 2006 eruption. The source of this transient sulfur smell was likely Iliamna (see section, "Iliamna Volcano").

Augustine Volcano is frequently active, close to populated areas, and is one of the most visible and accessible volcanoes in south-central Alaska. The volcano forms the bulk of Augustine Island, an 8 × 11 km (5 × 7 mi) island in the lower Cook Inlet. Uplifted Jurassic and Cretaceous sediments are exposed on the southern side of the island (Waitt and Beget, 2009). Augustine consists of a conical, central dome and lava flow complex surrounded by a more gently sloping apron of fragmental deposits. Its pre-2006 eruption height was 1,260 m (4,134 ft) and the exact change to summit elevation following the 2006 activity has yet to be determined. Repeated sector collapses during the late Holocene have produced debris avalanches into Cook Inlet (Beget and Kienle, 1992). Historical eruptions include significant activity in 1883, 1835, 1963–64, 1976, 1986, and 2006.

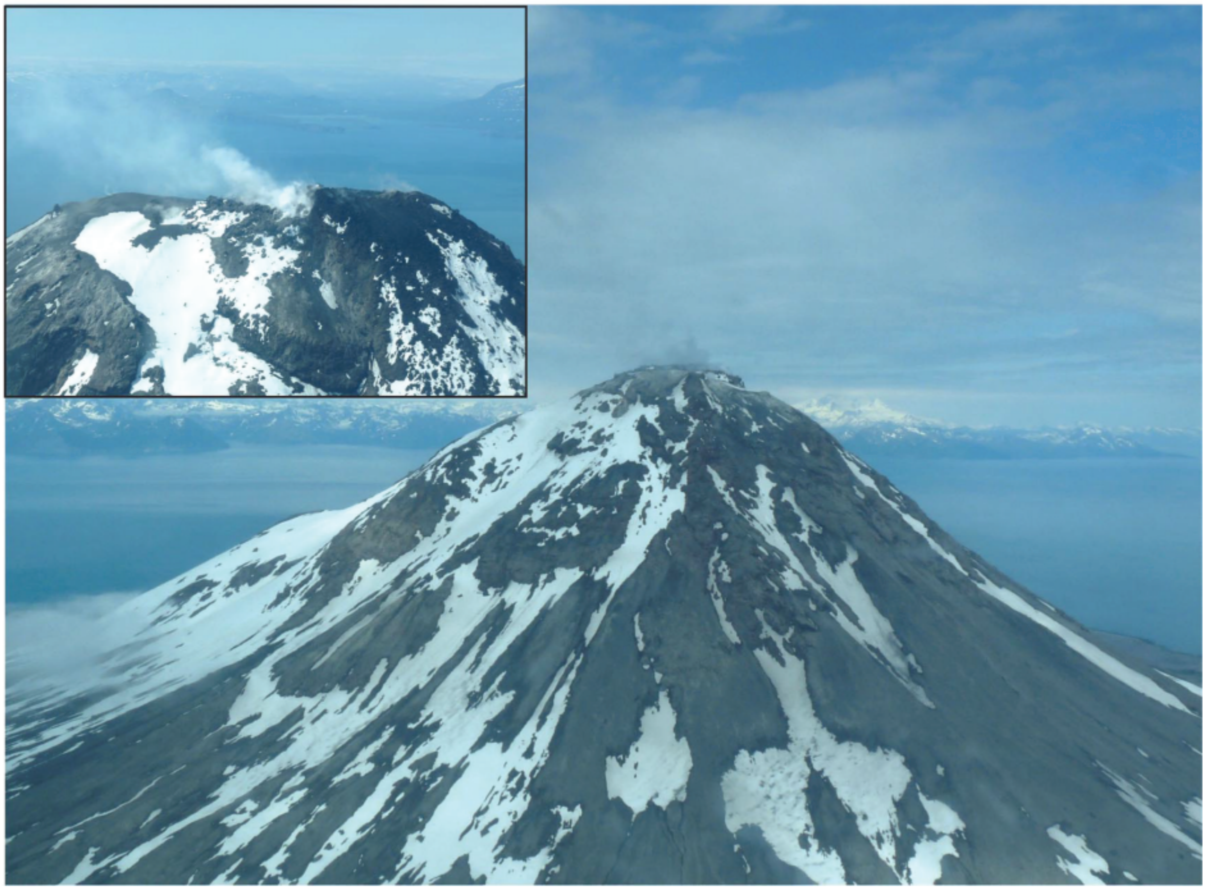

Figure 12. Oblique aerial view of Augustine's southern flank during a gas measurement flight, June 20, 2012. Inset shows close-up of the summit area, 2006 dome and lava flow, and active degassing and fumarolic area. Photographs by Christopher Kern, USGS/CVO. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=43221 and http://www.avo.alaska.edu/images/image.php? id=43231 (inset).

Fourpeaked Volcano

GVP New # 312260

CAVW# 1102-26-

58°46'N 153°40'W
2,104 m (6,903 ft)

Cook Inlet/Alaska Peninsula

SEISMICITY

During 2012, the Aviation Color Code and Volcano Alert Level at Fourpeaked remained **GREEN/NORMAL**. A minor uptick in seismicity prompted additional analysis of monitoring data by AVO.

From January through early August, seismicity in the Fourpeaked region remained relatively low with between one and six earthquakes detected per month (fig. 13). Beginning in mid-August, a shallow swarm of volcano-tectonic (VT) earthquakes began.

Intermittent seismicity continued through the rest of the year. The AVO 'swarm alarm' was triggered on November 25 when a swarm consisting of 18 events occurred over 2 days with individual event magnitudes ranging between M1.4 and M2.2.

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

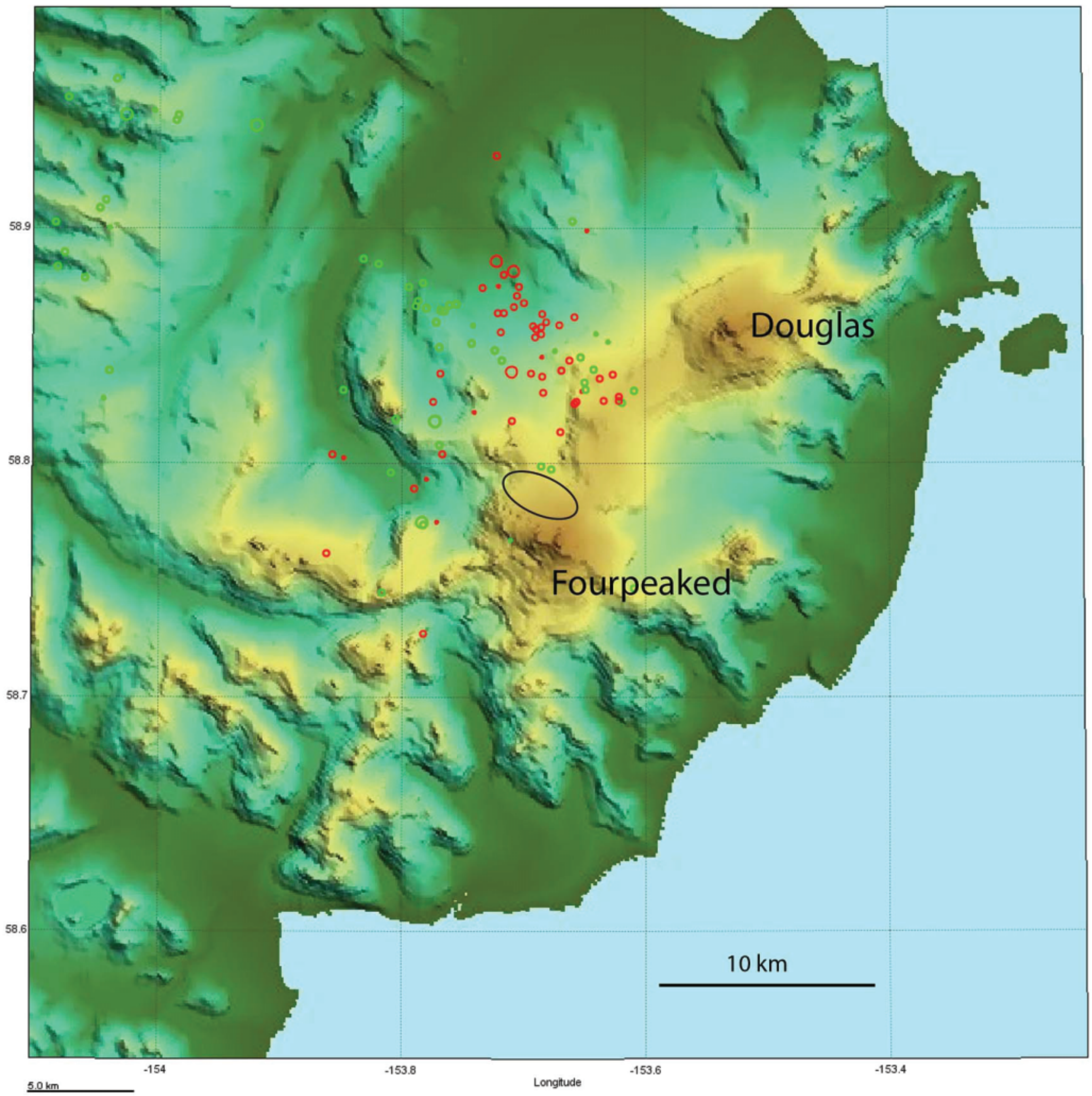

Figure 13. Epicenter map showing earthquakes (red and green circles) in the vicinity of Fourpeaked and Douglas volcanoes between August 14 and December 16, 2012. Circle diameters represent earthquake magnitude; most are M1.0 or less. Red circles are epicenters 5–13 km (3–mi) deep. Green circles are epicenters shallower than 5 km (3 mi). Earthquakes during this time cluster about 10 km (6.2 mi) northwest of the Fourpeaked swarm discussed in Gardine and others (2011). Oval indicates the approximate location of phreatic vents through the glacial ice in 2006 (Neal and others, 2009b).

Martin Volcano

GVP New # 312140

CAVW# 1102-14-

58°10'N 155°21'W
1,860 m (6,102 ft)

Alaska Peninsula

ELEVATED SEISMICITY, VAPOR PLUMES

Mount Martin is one of the Katmai Group of volcanoes within Katmai National Park and Preserve on the Alaska Peninsula. Martin has no confirmed historical eruptions, but a very active fumarolic field within a large, open crater at its summit has been the source of frequent robust plumes that are often called to AVO's attention. During 2012, in addition to reports of strong fumarolic activity, the AVO seismic network recorded bursts of elevated seismicity, similar to episodes seen in recent years (Dixon and Power, 2009; O'Brien and others, 2012). The Aviation Color Code and Volcano Alert Level at Martin remained **GREEN/NORMAL**.

In mid-April, AVO received three emails regarding activity at Martin. Observers in the area of Lower Ugashik Lake about 120 km (75 mi) to the southwest noted a plume that was larger than any that had been seen in more than 50 years in the area (fig. 14). Another observation from an overflight (fig. 15) reported a strong sulfur odor; this observer shared photographs of the cone and the summit crater with AVO. Comparisons with other recent photographs of Martin suggested no significant change in activity. Previous overflights of Martin routinely noted sulfur smell and gas measurement flights typically measure both SO_2 and H_2S (Doukas and McGee, 2007).

On June 27, climbers ascended the volcano and reported a strong sulfur odor upon reaching the crater rim (fig. 16). Gas concentration was strong enough to cause coughing and a burning-throat sensation. They described roaring and bubbling noises coming from the crater lake and three fumaroles located on the triangular peak "below the summit cone on the northeastern side of Mount Martin." Additionally, "snow on the entire final summit cone was tinged yellow from sulfur…." These attributes previously have been noted at Martin during many AVO field visits to the volcano and are considered typical.

AVO Observes the 100th Anniversary of the 1912 Eruption of Novarupta and Katmai

The world's largest volcanic eruption of the 20th century broke out at Novarupta on June 6, 1912, filling with hot ash what came to be called the Valley of Ten Thousand Smokes and spreading downwind more fallout than all other historical Alaskan eruptions combined. Although almost all the magma erupted at the Novarupta vent, most of it was stored beneath Mount Katmai, 10 km (6.2 mi) away. Mount Katmai collapsed during the eruption. Airborne ash from the 3-day event blanketed all of southern Alaska; its gritty fallout was reported as far away as Dawson, Ketchikan, and Puget Sound. Volcanic dust and sulfurous aerosol were detected within days over Wisconsin and Virginia; within 2 weeks over California, Europe, and North Africa; and in latter-day ice cores recently drilled on the Greenland ice cap (Hildreth and Fierstein, 2012).

AVO marked and publicized the 100th anniversary of this eruption in several ways. AVO hosted a series of 10 free public lectures in conjunction with the Alaska Public Lands Information Center and created a special section on our Web site (https://www.avo.alaska.edu/Katmai2012/#), which holds an interactive timeline of eruption events, including photographs and direct quotes, a curated bibliography, short video clips of Katmai, and a slideshow of Katmai-area volcano images. In addition, AVO hosted a "100 years ago" twitter feed (http://twitter.com/Katmai1912) where events were tweeted as they unfolded exactly 100 years ago..

Figure 14. View of towering vapor plume rising from Martin volcano as seen from the outlet of Lower Ugashik Lake, about 120 km (75 mi) to the southwest of the volcano, April 11, 2012. Photograph by Robert Dreeszen, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=42411.

Mount Martin and adjacent Mount Mageik are stratovolcanoes within Katmai National Park and Preserve on the Alaska Peninsula (fig. 1) about 475 km (295 mi) southwest of Anchorage. Martin's summit cone sits at an elevation of roughly 1,860 m (6,102 ft) ASL. A summit crater about 300 m (980 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 fumarolic 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).

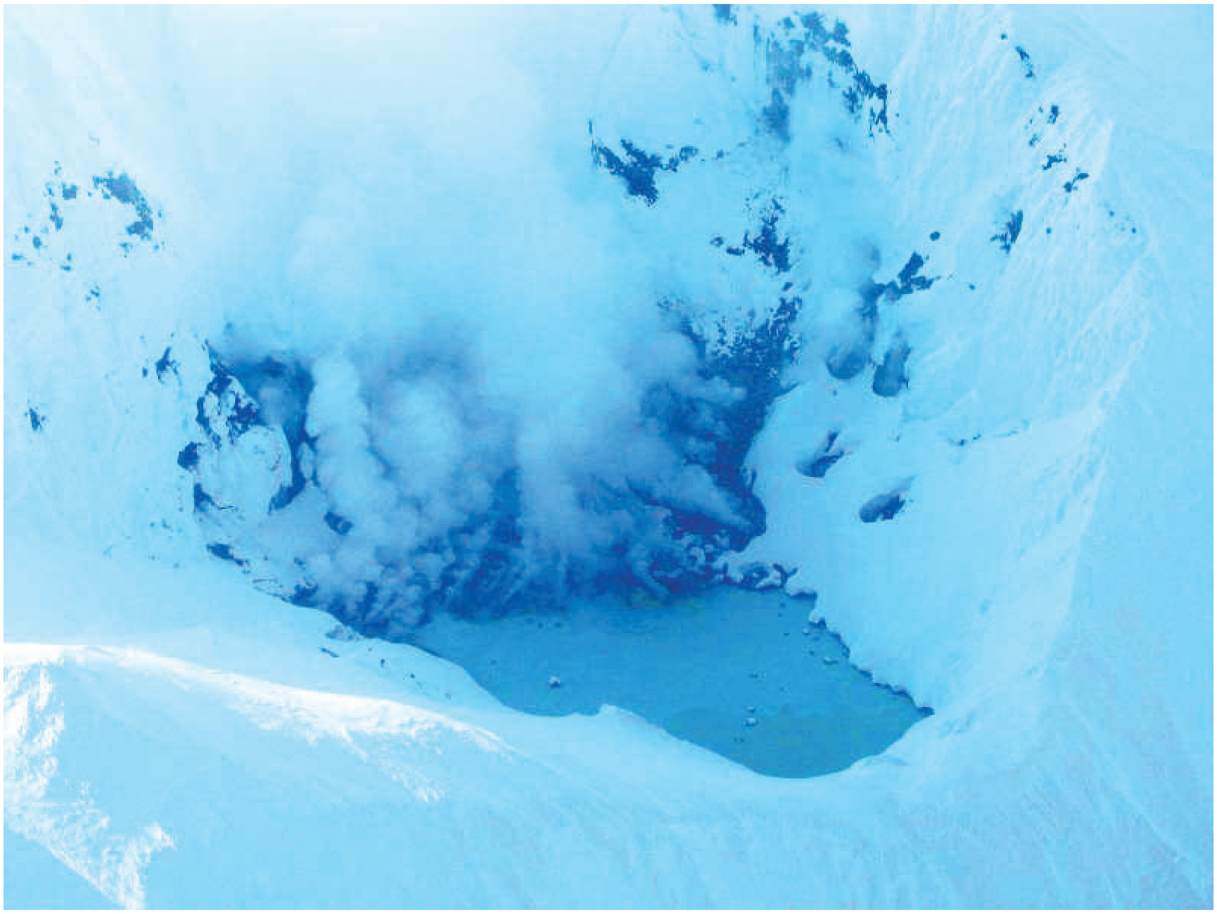

Figure 15. Close up view of the summit crater at Martin volcano, April 11, 2012. The crater is about 300 m (980 ft) in diameter. Photograph by Tammy Carmack, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=42491.

Figure 16. View of the Martin fumarolic plume on June 27, 2012, during an ascent of the volcano. Photograph by Mark and Joan Strobel, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php?id=44021.

Aniakchak Volcano

GVP New # 312090

CAVW# 1102-09-

56°54'N 158°13'W
1,341 m (4,400 ft)

Alaska Peninsula

PERIODS OF INCREASED SEISMICITY; EARTHQUAKE SWARM AND POSSIBLE TREMOR

In January 2012, the Aviation Color Code and Volcano Alert Level at Aniakchak was **GREEN/NORMAL**. This status remained unchanged through 2012, although intermittent seismicity including tremor and repeated short-lived swarms of low-frequency events were detected during the year.

Sequences of low-frequency events lasting 10 minutes were detected at least eight times during the year: January 29, February 7, March 29, April 4, May 2, May 16, October 22, and December 21. Examples of these swarms are shown in figure 17. Other low frequency earthquakes were detected during March–May and included events up to 30 km (19 mi) deep (fig. 18). A 3-minute long tremor-like signal was recorded at Aniakchak at 11:59 UTC on May 8.

On August 3, the AEIC (now the AEC) recorded an M4.7 earthquake 32 km (20 mi) west-northwest of Yantarni volcano and 38 km (24 mi) northeast of Aniakchak. There were at least 30 aftershocks detected with magnitudes between M1.7 and M4.3. Although this was considered non-volcanic seismicity, there was some discussion at AVO regarding the potential for regional seismicity to precede eruptive activity.

During the last week of November, deep long-period earthquakes also were detected beneath the caldera. There was an M5.75 tectonic earthquake west of Anchorage on December 3, an event large enough for detection at Little Sitkin, about 1,600 km (990 mi) southwest. Some induced seismicity at Aniakchak may have occurred following this distal event.

Aniakchak is a circular caldera 10 km (6.2 mi) in diameter and as deep as about 1 km (3,280 ft) from the rim to the caldera floor (fig. 19). 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). 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, 2.5 km (1.5 mi) in diameter and rising 430 m (1,410 ft) above the floor of the caldera. The only historical eruption of Aniakchak, a powerful explosive event that covered a large portion of the eastern Alaska Peninsula with ash, occurred in 1931 (Nicholson and others, 2011). Isolated low-frequency events beneath Aniakchak are not uncommon in the history of seismic monitoring of this young, explosive volcano (McGimsey and others, 2014). Aniakchak also is notorious for anomalous seismic signals during the adverse weather and icing conditions common during the Alaska Peninsula winters (Neal and others, 2011).

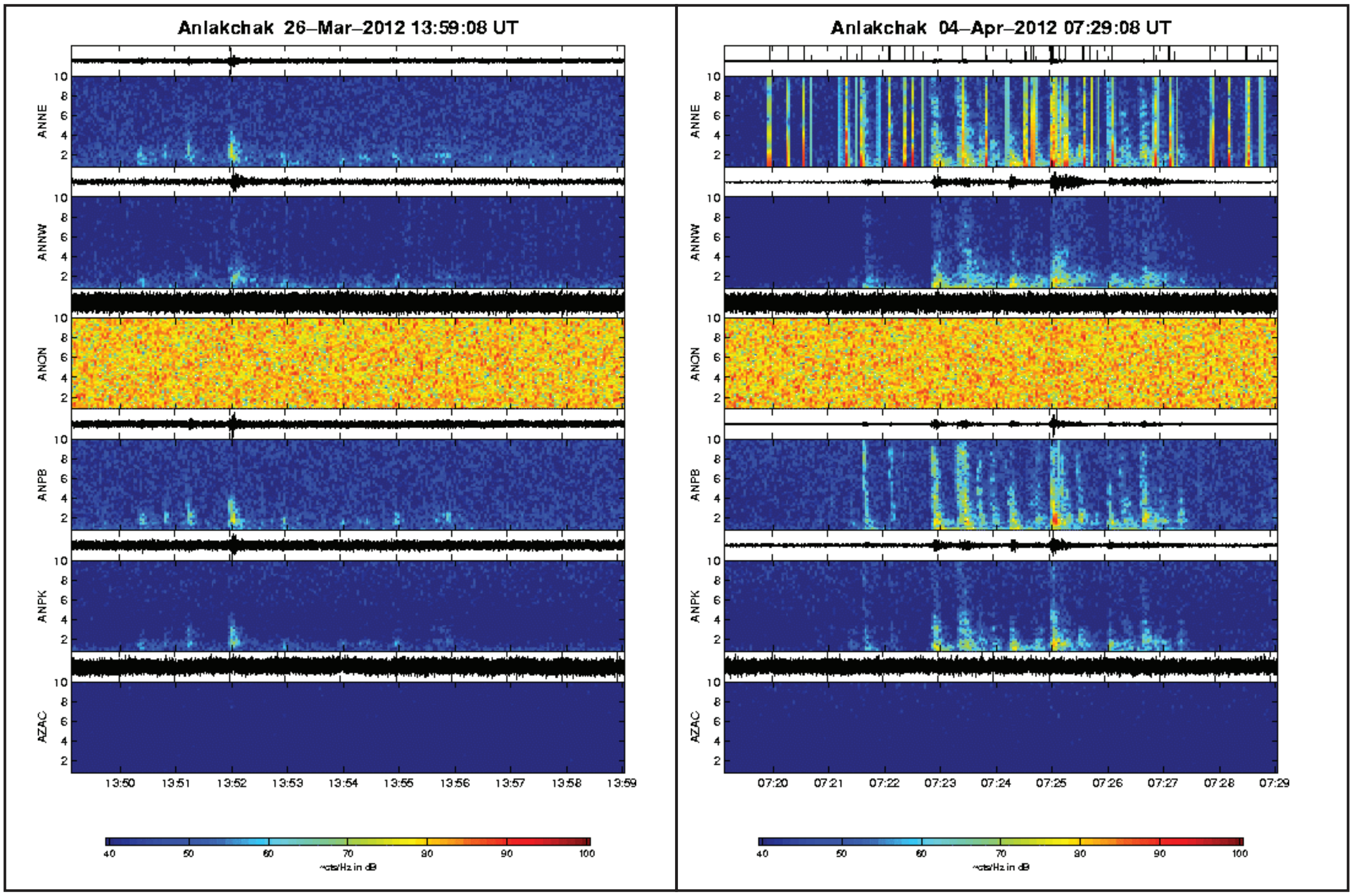

Figure 17. Two spectrograms from the Aniakchak volcano seismic network (six stations; ANON and AZAC are not operational) showing brief swarms of low-frequency dominated events beneath the caldera on March 26 and April 4, 2012. Time is shown on the *x*-axis. Frequency is shown on the *y*-axis in Hz; warmer colors represent higher amounts of energy or signal strength.

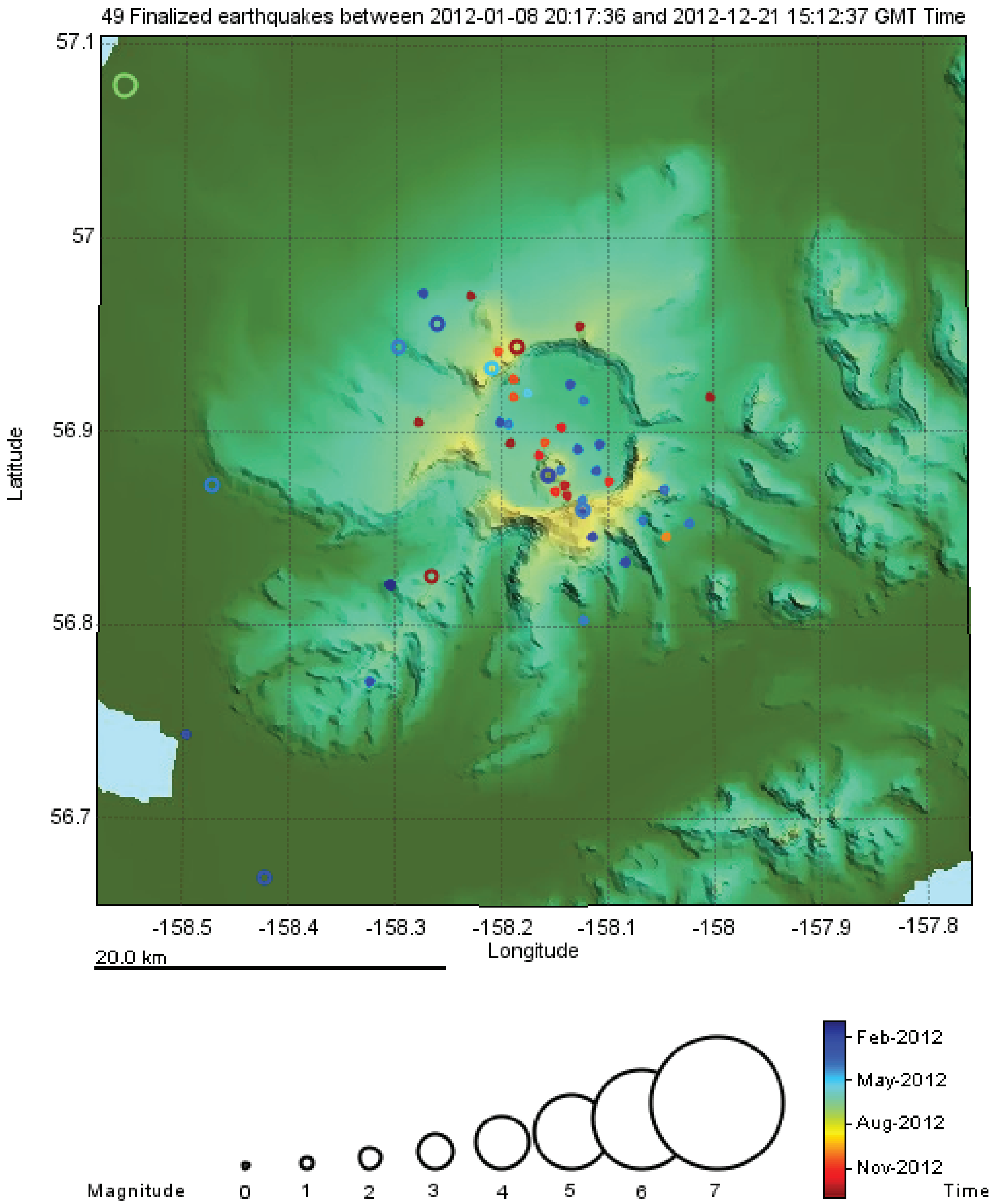

Figure 18. Seismicity located in the vicinity of Aniakchak Crater in 2012. The large regional event, 29 km (18 mi) northwest of Vent Mountain, a prominent post-caldera cone within the caldera, had a magnitude of 2.4 (see light green circle showing event epicenter in upper left of map plot). Colors of epicenters depict time of event, and size of circle represents earthquake magnitude (see scale at bottom).

Figure 19. Oblique aerial view of 10-km (6-mi) wide Aniakchak Caldera on the Alaska Peninsula. Photograph by Roy Wood, National Park Service, March 10, 2011. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=56664.

Cleveland Volcano

GVP New # 311240

CAVW# 1101-24-

52°49'N 169°57'W
1,730 m (5,676 ft)

Chuginadak Island, east-central Aleutian Islands

LAVA EXTRUSION IN SUMMIT CRATER, EXPLOSIVE DESTRUCTION OF FIVE DOMES, SMALL ASH CLOUDS

2012 saw continued eruptive activity at Cleveland volcano with intermittent small ash cloud production, vapor plumes, and at least four episodes of lava effusion in the summit crater. Persistently elevated surface temperatures also were detected in satellite data, likely associated with lava at the surface or hot gases emitted from the summit vent, or both. Activity and observations are summarized in tables 5 and 6.

In 2012, Cleveland remained unmonitored by ground-based instrumentation. Accordingly, AVO used remote methods, such as satellite image analysis and, increasingly, infrasound and ground coupled airwaves (Fee and others, 2010; De Angelis and others, 2012) to detect activity at the volcano. Elevated surface temperatures at the volcano likely reflected the presence of a hot, open conduit in the summit crater, episodes of lava fountaining, and, at times accumulation of new lava in the bottom of the crater. The presence of lava in the summit crater indicated an increased potential for explosion or overtopping of the crater and avalanching of hot debris down the flank of the cone. The use of satellite images for monitoring activity is limited by frequent cloudy conditions over the volcano, thus the record of observation is incomplete.

Cleveland began 2012 at Aviation Color Code and Volcano Alert Level **YELLOW/ADVISORY** after a late December 2011 explosive event that sent a small ash cloud up to 15,000 ft (4.6 km; McGimsey and others, 2014) ASL. Clear views of the volcano in satellite images consistently showed elevated surface temperatures in the vicinity of the summit throughout the year. Satellite images also showed that the 200-m-diameter (660-ft) summit crater had been reamed of lava and showed little evidence of deposits mantled on the crater floor. A pit in the approximate center of the crater floor measured 50–60 m (160–200 ft) across. Continuing low-level activity may have produced a more significant blanket of tephra and scattered shallow pits on the crater floor by January 11, 2012.

On January 30, a new lobe of lava about 40 m (130 ft) across was detected at the bottom of the summit crater. On January 31, the Aviation Color Code and Volcano Alert Level was upgraded to **ORANGE/WATCH** due to the presence of this small lava flow and the increased potential for explosive dome destruction.

Table 5. Summary of Cleveland volcano activity in 2012.

[Compiled from AVO web site archives, internal logs, and master AVO chronology spreadsheet. AVHRR is Advanced Very High Radiometer. MODIS is Moderate Resolution Imaging Spectroradiometer. As a measure of elevated surface temperatures, “number of pixels” reported in parentheses are from an internal AVO database of daily satellite observations; this number is a very rough proxy for the intensity of elevated surface temperatures. Absence of elevated temperature entries may simply mean clouds obscure the ground. Elizabeth Redlinger and Kristi Wallace are gratefully acknowledged for early compilations of a master table of Cleveland’s historical activity and for maintaining the master chronology for AVO]

Date	Aviation Color Code/ Volcano Alert Level	Activity/Ash Cloud	Elevated surface temperatures, satellite sensor (number of pixels)	Ground, air, or other satellite observations	Seismic network and infrasound detection (see table 6)or other alarm triggers
01-02-12	YELLOW/ADVISORY	Elevated temperature	MODIS (?)	–	–
01-03-12	YELLOW/ADVISORY	–	–	Pit in the summit crater floor 50 to 60 m across. Summit crater has deepened. No lava visible.	–
01-08-12	YELLOW/ADVISORY	–	–	January 8 TerraSAR-X image confirms deepening of summit crater since December 19.	–
01-11-12	YELLOW/ADVISORY	–	–	Crater floor blanketed with tephra	–
01-12-12	YELLOW/ADVISORY	Fumarolic cloud, elevated temperature	AVHRR (4) MODIS (2)	Crater mostly obscured by fume in WorldView-2 image. http://www.avo.alaska.edu/images/image.php?id=41751	–
01-17-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (?)	–	–
01-24-12	YELLOW/ADVISORY	–	–	No lava in summit crater. Crater about 45 m deep.	–
01-29-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (?)	–	–
01-30-12	YELLOW/ADVISORY	New lava flow (#1)		Dome 40 m across.	–
01-31-12	ORANGE/WATCH: New lava in crater	–	–	–	–
02-03-12	ORANGE/WATCH	Lava effusion?	–	–	–
02-07-12	ORANGE/WATCH	Lava effusion?	–	Dome 50 m across.	–
02-13-12	ORANGE/WATCH	Elevated temperature	AVHRR (1) MODIS (1)	–	–
02-14-12	ORANGE/WATCH	Fumarolic cloud, lava effusion	–	Dome 60 m across. No new tephra on flanks or crater rim. Pilot reports small puffs of white steam at 10–15 second intervals, dissipating 500 to 700 feet above summit.	–
02-19-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)		–
02-22-12	ORANGE/WATCH	Elevated temperature, lava effusion	AVHRR (2)	Dome growth continues; second lava flow atop earlier dome is 20 m across.	–
02-23-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	–	–
02-29-12	ORANGE/WATCH	Lava effusion	–	Dome is 60–70 m across.	–
03-03-12	ORANGE/WATCH	Elevated temperature	MODIS (1)	–	–
03-08-12	ORANGE/WATCH	Explosion, ash cloud. Small ash cloud, dissipated quickly	–	Explosion detected 04:05 UTC.	–
03-10-12	ORANGE/WATCH	Explosion	–	Explosion detected 01:50 UTC.	–
03-11-12	ORANGE/WATCH	Elevated temperature	AVHRR (1) MODIS (1)	Summit dome destroyed. Crater partially filled with debris. Little evidence of tephra on volcano flanks. http://www.avo.alaska.edu/images/image.php?id=42071	–

Table 5. Summary of Cleveland volcano activity in 2012. —Continued

Date	Aviation Color Code/ Volcano Alert Level	Activity/Ash Cloud	Elevated surface temperatures, satellite sensor (number of pixels)	Ground, air, or other satellite observations	Seismic network and infrasound detection (see table 6)or other alarm triggers
03-12-12	ORANGE/WATCH	–	–	Scattered blocks about summit.	–
03-13-12	ORANGE/WATCH	Explosion	–	Explosion detected 22:55 UTC.	–
03-14-12	ORANGE/WATCH	–	–	Summit crater deepened after explosion.	–
03-18-12	ORANGE/WATCH	–	–	–	–
03-23-12	YELLOW/ADVISORY: No explosions since March 13	Elevated temperature	AVHRR (1)	–	–
03-25-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (1) MODIS (1)	–	–
03-26-12	YELLOW/ADVISORY	New lava flow in summit crater (#2)	–	New summit dome about 70 m across.	–
03-28-12	ORANGE/WATCH: New lava in crater	–	–	–	–
03-30-12	ORANGE/WATCH	–	–	Dome still intact.	–
04-03-12	ORANGE/WATCH	Elevated temperature	AVHRR (2)	–	–
04-04-12	ORANGE/WATCH	Explosion	–	Dome has been destroyed. Blocks 15 to 20 m across in summit crater.	Explosion recorded weakly on Okmok seismic and intrasound array, also Dillingham infrasound array.
04-05-12	ORANGE/WATCH	–	AVHRR (1)	–	–
04-07-12	ORANGE/WATCH	Two explosions, elevated temperature	AVHRR (2) MODIS (1)	Small ash cloud detected 64 km northeast below 20,000 feet.	Two explosions recorded on Makushin seismic network and Dillingham infrasound array. Similar in size to April 4 event.
04-12-12	ORANGE/WATCH	Elevated temperature	AVHRR (1) MODIS (1)	–	–
04-13-12	ORANGE/WATCH	Two explosions	–	–	Explosions recorded on Dillingham infrasound array at 16:04 UTC and 19:01 UTC.
04-14-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	Debris on snow south and east of summit within 500 m of rim.	–
04-15-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	–	–
04-16-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	–	–
04-17-12	ORANGE/WATCH	–	–	Blocks on crater floor, no lava visible.	–
04-18-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	–	–
04-19-12	ORANGE/WATCH	Explosion, elevated temperature	–	–	Explosion at 12:38 UTC April 19 (?) recorded on Dillingham infrasound array, Makushin and Okmok seismic networks.
04-20-12	ORANGE/WATCH	Elevated temperature	AVHRR (2) MODIS (1)	–	–

Table 5. Summary of Cleveland volcano activity in 2012. —Continued

Date	Aviation Color Code/ Volcano Alert Level	Activity/Ash Cloud	Elevated surface temperatures, satellite sensor (number of pixels)	Ground, air, or other satellite observations	Seismic network and infrasound detection (see table 6)or other alarm triggers
04-25-12	ORANGE/WATCH	New lava flow in summit crater, elevated temperature (#3)	AVHRR (1)	Dome 25 m across. No ash on flanks.	–
04-28-12	ORANGE/WATCH	–	AVHRR (2) MODIS (1)	–	–
04-29-12	ORANGE/WATCH	Possible explosion (?)	–	April 25 dome destroyed, possibly in 16:14 UTC explosion.	Event of unknown origin at 16:14 UTC April 29 (?) noted on the Makushin network; inconclusive.
04-30-12	ORANGE/WATCH	–	MODIS (1)	–	–
05-03-12	ORANGE/WATCH	New lava flow in summit crater (#4)	–	Dome 25 m across.	–
05-04-12	ORANGE/WATCH	Explosion	–	–	Explosion detected 18:54 UTC on Dillingham array and on Makushin seismic and infrasound array.
05-05-12	ORANGE/WATCH	Explosion	–	–	Explosion detected 09:20 UTC on Makushin and Dillingham infrasound arrays. Amplitude about one-half April 4 event.
05-06-12	ORANGE/WATCH	–	–	No sign of lava dome in summit crater.	–
05-09-12	ORANGE/WATCH	–	–	Blocks litter summit crater floor.	–
05-13-12	ORANGE/WATCH	Elevated temperature	AVHRR (3)	–	–
05-14-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	–	–
05-15-12	ORANGE/WATCH	–	–	No dome in summit crater.	–
05-29-12	ORANGE/WATCH	–	–	No change since May 9.	–
05-30-12	YELLOW/ADVISORY: No explosions or lava effusion since May 9	–	–	–	–
06-01-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (3) MODIS (1)	–	–
06-02-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (1)	–	–
06-03-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (1)	–	–
06-04-12	YELLOW/ADVISORY	Explosion	–	–	Explosion at 10:08 UTC recorded on Dillingham array.
06-05-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (3)	–	–
06-06-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (2) MODIS (1)	–	–
06-07-12	YELLOW/ADVISORY	Elevated temperature	–	Very strong sulfur smell reported from Nikolski. Also distinct plume from Cleveland summit.	–
06-08-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (1)	–	–
06-09-12	YELLOW/ADVISORY	–	–	Minor ash visible on upper flanks. Crater appears partially filled with snow. http://www.avo.alaska.edu/images/image.php? id=43051	–

Table 5. Summary of Cleveland volcano activity in 2012. —Continued

Date	Aviation Color Code/ Volcano Alert Level	Activity/Ash Cloud	Elevated surface temperatures, satellite sensor (number of pixels)	Ground, air, or other satellite observations	Seismic network and infrasound detection (see table 6)or other alarm triggers
06-10-12	YELLOW/ADVISORY	Elevated temperature	–	No dome in summit crater. New tephra deposits to NNW and NE mostly confined to drainages extending about 1.5 km downslope. New deposits patchy on SW to SE flanks extending downslope about 1 km. Evidence of melting and flowage on all flanks.	–
06-12-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (2) MODIS (1)	–	–
06-13-12	YELLOW/ADVISORY	Elevated temperature	AVHRR (2)	–	–
06-16-12	YELLOW/ADVISORY	Elevated temperature	MODIS (1)	–	–
06-17-12	YELLOW/ADVISORY	–	–	No dome in summit crater, only several large blocks.	–
06-19-12	ORANGE/WATCH: Ash cloud detected in Web camera image	Explosion and ash cloud. Ash estimated to 18,000 feet based on pilot report	AHVRR (3) MODIS (1)	Pilot report, Web camera, and infrasound detect an ash producing explosion. AVHRR satellite image of ash cloud drifting east from the volcano.	Explosion at 22:04 UTC.
06-20-12	ORANGE/WATCH	Elevated temperature	AVHRR (5) MODIS (1)	Possible weak plume seen in Web camera.	–
06-21-12	ORANGE/WATCH	Elevated temperature	AVHRR (2)	Tephra-blanketed summit crater slightly deeper since June 17. New depression about 30 m across and 10 m deep likely marks recent vent.	–
06-23-12	ORANGE/WATCH	Elevated temperature	AVHRR (2) MODIS (1)	–	–
06-25-12	ORANGE/WATCH	–	–	Possible new lava flow, 25 m across, in summit crater; later discounted.	–
06-26-12	ORANGE/WATCH	Explosion, elevated temperature. Small ash cloud 22,000 to 25,000 feet in AVHRR and MODIS.	AVHRR (3) MODIS (1)	–	Airwaves from explosion registered on networks from Makushin to Tanaga at 11:19 UTC. Also recorded on Dillingham infrasound array and new Adak sensor.
06-28-12	ORANGE/WATCH	Elevated temperature	AVHRR (1)	Summit crater has a tephra filled funnel-shaped inner crater about 110 m across and 50 m deep. This feature present on June 25 but was widened and deepened by the June 26 explosion.	–
06-29-12	ORANGE/WATCH	Elevated temperature	AVHRR (2) MODIS (1)	–	–
07-03-12	ORANGE/WATCH	–	–	No changes since 28 June.	–
07-06-12	ORANGE/WATCH	Degassing		AVO Web camera shows gas plume at summit elevation extending about 20 mi.	–
07-08-12	ORANGE/WATCH	–	MODIS (1)		
07-10-12	ORANGE/WATCH	–	AVHRR (2)	–	–
07-12-12	ORANGE/WATCH	Explosion. Small, discrete ash cloud southeast of volcano at 06:12 UTC.	AVHRR (2)	–	Ground coupled airwaves at Okmok, Korovin, Makushin, Akutan, and Kanaga.
07-16-12	ORANGE/WATCH	–	AVHRR (1)	–	–
07-17-12	ORANGE/WATCH	–	AVHRR (1)	–	–

Table 5. Summary of Cleveland volcano activity in 2012. —Continued

Date	Aviation Color Code/ Volcano Alert Level	Activity/Ash Cloud	Elevated surface temperatures, satellite sensor (number of pixels)	Ground, air, or other satellite observations	Seismic network and infrasound detection (see table 6)or other alarm triggers
07-18-12	ORANGE/WATCH	–	AVHRR (2) MODIS (1)	The summit crater is mantled by tephra and blocks. The inner crater is about 40 m across.	–
07-20-12	ORANGE/WATCH	–	AVHRR (1)	–	–
07-24-12	ORANGE/WATCH	–	AVHRR (1) MODIS (1)	–	–
07-26-12	ORANGE/WATCH	–	AVHRR (2) MODIS (1)	–	–
07-27-12	ORANGE/WATCH	–	AVHRR (2)	–	–
07-28-12	ORANGE/WATCH	–	AVHRR (1)	–	–
07-29-12	ORANGE/WATCH	–	AVHRR (1)	Summit crater open. No new lava.	–
07-30-12	ORANGE/WATCH	–	AVHRR (1) MODIS (1)	–	–
08-03-12	ORANGE/WATCH	–	AVHRR (1)	–	–
08-04-12	ORANGE/WATCH	Explosion	AVHRR (1) MODIS (1)	–	Explosion detected at 16:38 UTC on Okmok, Akutan, and Dillingham infrasound arrays. Also recorded on seismic stations at Nikolski and Korovin.
08-50-12	ORANGE/WATCH	–	AVHRR (6) MODIS (1)	–	–
08-06-12	ORANGE/WATCH	–	AVHRR (2)	–	–
08-07-12	ORANGE/WATCH	–	AVHRR (2) MODIS (1)	–	–
08-08-12	ORANGE/WATCH	–	AVHRR (4) MODIS (2)	–	–
08-09-12	ORANGE/WATCH	–	AVHRR (5) MODIS (1)	–	–
08-11-12	ORANGE/WATCH	–	AVHRR (1) MODIS (1)	–	–
08-17-12	ORANGE/WATCH	Explosion		–	Explosion detected at 08:48 UTC.
08-20-12	ORANGE/WATCH	Explosion and ash cloud. GOES captures drifting cloud from 02:55 explosion.	AVHRR (1) MODIS (1)	–	Explosion detected at 02:55 UTC. Weak signals on the Okmok and Korovinnetworks and the Nikolski broadband.
08-24-12	ORANGE/WATCH	–	AVHRR (1)	–	–
08-27-12	ORANGE/WATCH	–		Summit crater is a tephra-covered funnel surrounding a central pit ~10 m across. No dome.	–
09-05-12	YELLOW/ADVISORY: No explosions since August 20, no lava effusion since early May	–	–	–	–
09-14-12	YELLOW/ADVISORY	–	MODIS (1)	–	–
09-19-12	YELLOW/ADVISORY	–	AVHRR (1)	–	–
09-28-12	YELLOW/ADVISORY	–	AVHRR (1)	–	–
10-20-12	YELLOW/ADVISORY	–	AVHRR (3)	–	–
10-22-12	YELLOW/ADVISORY	–	AVHRR (3)	–	–
10-24-12	YELLOW/ADVISORY	–	AVHRR (2)	–	–
10-26-12	YELLOW/ADVISORY	–	AVHRR (1)	–	–

Table 5. Summary of Cleveland volcano activity in 2012. —Continued

Date	Aviation Color Code/ Volcano Alert Level	Activity/Ash Cloud	Elevated surface temperatures, satellite sensor (number of pixels)	Ground, air, or other satellite observations	Seismic network and infrasound detection (see table 6)or other alarm triggers
10-27-12	YELLOW/ADVISORY	–	AVHRR (2)	–	–
10-28-12	YELLOW/ADVISORY	–	MODIS (1)	–	–
10-29-12	YELLOW/ADVISORY	–	AVHRR (3)	–	–
10-30-12	YELLOW/ADVISORY	–	AVHRR (4) MODIS (1)	Minor steam from bowl-shaped summit crater. No new lava.	–
11-06-12	YELLOW/ADVISORY	–	AVHRR (1) MODIS (1)	–	–
11-07-12	YELLOW/ADVISORY	–		Summit crater unchanged. No new lava.	–
11-10-12	ORANGE/WATCH: Explosion. Small ash cloud from Cleveland in satellite image	Explosion and ash cloud. Ash cloud at 20:47 UTC drifting slowly eastward. Ash last observed about 60 miles south of Dutch Harbor at 03:43 UTC Nov 11.	AVHRR (1) MODIS (1)	Following the approximately 20:25 UTC explosion, dark flowage deposits extend down the east flank as much as 1 km. Summit crater emitting steam.	Ground-coupled airwaves across the Makushin network.
11-15-12	ORANGE/WATCH	–	–	No sign of new lava in summit crater.	–
11-20-12	ORANGE/WATCH	–	AVHRR (1) MODIS (1)	–	–
11-21-12	YELLOW/ADVISORY	–	AVHRR (1)	No sign of new lava in summit crater.	–
11-22-12	YELLOW/ADVISORY	–	MODIS (1)	–	–
11-23-12	YELLOW/ADVISORY	–	MODIS (1)	–	–
11-24-12	YELLOW/ADVISORY	–	AVHRR (1)	–	–
11-29-12	YELLOW/ADVISORY	–	MODIS (1)	No sign of new lava in summit crater.	–
11-30-12	YELLOW/ADVISORY	–	AVHRR (2) MODIS (1)	–	–
12-01-12	YELLOW/ADVISORY	–	AVHRR (3)	–	–
12-03-12	YELLOW/ADVISORY	–	AVHRR (3)	–	–
12-12-12	YELLOW/ADVISORY	–	AVHRR (1)	–	–
12-25-12	YELLOW/ADVISORY	–	–	No sign of new lava in summit crater.	–

Table 6. Summary of infrasound-detected explosions at Cleveland volcano, 2011–2012.

[Events are numbered following the initiation of an infrasound alarm system at AVO in late 2011. Compiled by Matt Haney, AVO/USGS. On April 29, 2012, a very weak signal was detected on the Makushin seismic network at 16:14 UTC; first considered a possible explosion, reanalysis was inconclusive (M. Haney, written commun. November 27, 2013)]

MM/DD/YYYY	HH:MM (UTC)	Event No.	MM/DD/YYYY	HH:MM (UTC)	Event No.
12-25-11	12:13	Event 1	04-19-12	12:38	Event 12
12-25-11	15:32	Event 2	05-04-12	18:54	Event 13
12-29-11	13:12	Event 3	05-05-12	09:20	Event 14
03-08-12	04:05	Event 4	06-04-12	10:08	Event 15
03-10-12	01:50	Event 5	06-19-12	22:04	Event 16
03-13-12	22:55	Event 6	06-26-12	11:19	Event 17
04-04-12	09:12	Event 7	07-12-12	05:52	Event 18
04-07-12	00:35	Event 8	08-04-12	16:38	Event 19
04-07-12	05:26	Event 9	08-17-12	08:48	Event 20
04-13-12	16:04	Event 10	08-20-12	02:55	Event 21
04-13-12	19:01	Event 11	11-10-12	20:25	Event 22

On February 3, satellite data showed no significant change within the summit crater. By February 7, the dome had grown to about 50 m (160 ft) across and 1 week later, 60 m (200 ft; fig. 20). On February 22, additional new lava had broken the surface of the dome producing a 20-m-diameter (66-ft) lobe atop the existing lava pad. Evidence of continued effusion was reported through the end of February and slightly elevated temperatures were reported during clear conditions.

Three explosions occurred from the Cleveland summit crater in the first 2 weeks of March (tables 5 and 6); the March 8 explosion produced a small ash cloud that dissipated quickly. Details of how much of the new lava dome was destroyed in each explosion are unknown, but by March 11, it was entirely removed. Cloudy conditions prevailed and ash emissions that may have been produced after March 8 went unnoticed. On March 23, the Aviation Color Code and Volcano Alert Level was downgraded to **YELLOW/ADVISORY** based on the lack of evidence of renewed lava effusion.

On March 26, a new lava flow about 70 m (230 ft) across was detected within the crater. On March 28, the Aviation Color Code and Volcano Alert Level was upgraded to **ORANGE/WATCH**. By April 4, the dome was gone, likely removed in an explosion at about 09:12 UTC on April 4 (table 6). Subsequent satellite images showed that large blocks, 15–20 m (50–65 ft) across, littered the crater floor. Four additional explosions occurred between April 7 and April 19 during a period of frequently elevated temperatures detected in satellite images (table 5). No unequivocal ash clouds were detected following each event; however, weather and satellite overpass timing could have played a role. The AVO Web camera was not functioning during this time.

Elevated surface temperatures persisted through April and into May. By April 25, a new dome had appeared in the crater, only to be destroyed sometime before April 29. An ambiguous seismic event had been recorded by the Makushin network at 16:14 UTC on April 29. It may have been related to the dome's demise, but this remains inconclusive (M. Haney, USGS/AVO, written commun., November 2013). On May 3, the third detected lava flow of 2012 was observed in the crater forming a dome about 25 m (82 ft) in diameter.

Explosions occurred on May 4 and 5, but no ash cloud or strong thermal signal was noted for either event. Satellite observations on May 6 showed that the May 3 lava dome was gone, presumably destroyed during the May 4–5 explosions. After 3 weeks with no further explosions and only rare instances of elevated surface temperature, the Aviation Color Code and Volcano Alert Level was downgraded to **YELLOW/ADVISORY** on May 30. An AVO staff member flying near Cleveland noted white steam rising from the crater.

Cleveland remained at **YELLOW/ADVISORY** despite the detection of another explosion by infrasound on June 4. Only minor tephra and possibly flowage deposits were noted on a June 9 satellite image (fig. 21). On June 19, an explosion produced an ash cloud seen by a pilot, and the cloud also was captured on the AVO Web camera and detected by infrasound. The pilot estimated the cloud height to be 35,000 ft (11 km) ASL. Following detection of the explosion and confirmation of a high ash cloud, AVO upgraded the Aviation Color Code and Volcano Alert Level to **ORANGE/WATCH**.

Several more explosions occurred in late June, July, August, and November; all were detected either on infrasound networks or distant seismic stations. Three of these produced small ash clouds detected by satellite images and one by the AVO Web camera (fig. 22). Satellite observations of the volcano documented minor changes in the summit crater but no additional, intact lava flows were noted through the end of 2012.

The 2012 activity at Cleveland is a continuation of the intermittent explosive and effusive activity that has characterized the volcano for much of the time since its last significant eruption in 2001 (Dean and others, 2004). Cleveland forms the western part of Chuginadak Island, an uninhabited island in the east-central Aleutians about 73 km (45 mi) west of the community of Nikolski, and 1,500 km (930 mi) southwest of Anchorage. Historical eruptions have been characterized by short-lived ash explosions, lava fountaining, lava flows, and pyroclastic avalanches down the flanks. In February 2001, three explosive events produced ash clouds as high as 12 km (39,000 ft) ASL, a rubbly lava flow, and a hot avalanche that reached the sea (Dean and others, 2004). Cleveland is unmonitored by ground-based geophysical instrumentation. In 2011, AVO began development of an infrasound alarm technique to detect explosions at Cleveland (De Angelis and others, 2012.)

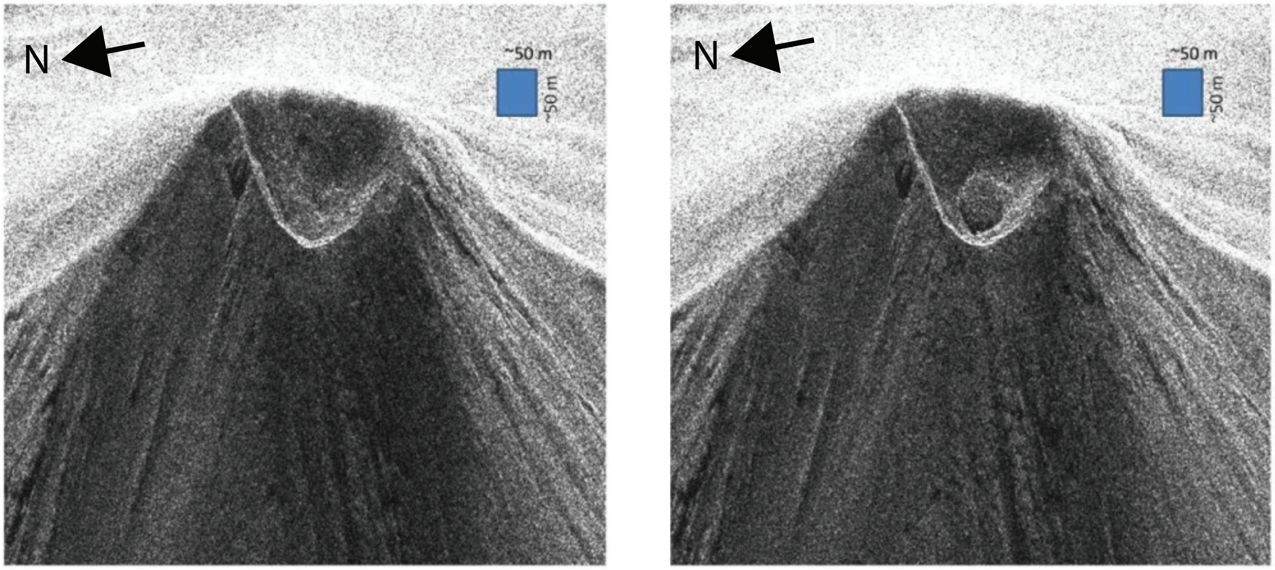

Figure 20. Comparison of TerraSAR-X images of Cleveland volcano on January 19, 2012, when the summit crater hosted no lava (left) and February 10, 2012, following extrusion of new lava forming a dome about 50–60 m (160–200 ft) across (right). Images courtesy Zhong Lu, USGS/CVO. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=41851 and 41861.

Figure 21. True color Worldview-2 image of Cleveland volcano collected on June 9, 2012. Note dark streaks of recent tephra atop the snowfield on the upper flanks of the volcano. Image copyright Digital Globe™, 2012, prepared by D.Schneider, USGS/AVO. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=43051.

Figure 22. Images of the June 19, 2012, explosion from Cleveland. (Left) AVO Web camera image of the small eruption cloud (circled) rising from the summit of Cleveland volcano on June 19, 2012, at about 22:14 UTC. The ground-coupled infrasound detection of the explosion occurred at 22:04 UTC, or about 10 minutes prior to the Web camera image. (Right) AVHRR satellite image from 23:43 UTC, about 90 minutes after the Web camera image. The ash cloud (blue) is detached from the volcano and has drifted east; the estimated altitude of the ash cloud was about 18,000 ft (5.5 km) ASL based on a U.S. Coast Guard pilot report.

Kanaga Volcano

GVP New # 311110

CAVW# 1102-03-

51°55'N 177°10'W
1,307 m (4,288 ft)

Kanaga Island, western Aleutian Islands

PHREATIC (?) EXPLOSION, LIMITED ASH FALL, NEW FISSURE ACROSS THE SUMMIT CRATER

Kanaga volcano in the western Aleutians last erupted in 1993 (McGimsey and Neal, 1996; Waythomas and others, 2002). Following the installation of a seismic network in 1999, the volcano has shown little evidence of unrest or activity and has remained at Aviation Color Code and Volcano Alert Level **GREEN/NORMAL**. In 1996, a report of possible ash above the summit may have been related to cooling and mass wasting of material emplaced in the 1993–1995 eruption (Neal and McGimsey, 1997).

An increase in seismic activity at Kanaga was first noted on February 18 during a routine seismic check by AVO seismologist S. Stihler, who reported a tremor-like event (interpreted as a possible explosion) followed by smaller events over the next hour (fig. 23). A possible correlative airwave occurred on the Adak seismic station 40 km (25 mi) northeast of Kanaga about 2 minutes after the tremor event (M. Haney, USGS/AVO, written commun., 2012). Ten minutes after the tremor event, a faint ash signal in satellite images may have been a small ash cloud from Kanaga, drifting to the east at an altitude of about 6 km (19,700 ft) ASL. Based on these observations, AVO upgraded the Aviation Color Code and Volcano Alert Level to **YELLOW/ADVISORY**. Additional analysis of the seismic signal, “reduced displacements,” showed relatively small values, consistent with hydrothermal or possibly phreatic activity (S. McNutt, UAFGI, written commun., 2012).

Adak resident M. Tillion contacted AVO by telephone on February 19 to share photographs and observations of Kanaga on the day after the possible explosion at about 12:26 Adak time or 10:26 UTC (fig. 24). From the White Alice site, west of the community of Adak, a resident noted an acrid odor that caused throat irritation. Kanaga volcano, 37 km (23 mi) northwest of Adak, was steaming strongly from the summit; M. Tillion thought that the plume may have contained some ash but further analysis suggests these were just shadowed clouds. There was, however, evidence of tephra or flowage deposits on the eastern flank extending down from the summit area.

Cloudy conditions prevented any direct observations throughout much of February. Slightly elevated surface temperatures at the summit were noted in satellite images on February 21. On February 23, four bursts of tremor-like events were recorded on the Kanaga network. Satellite images from February 26 showed that the summit crater was clear with no evidence of ongoing eruptive activity. Seismicity remained low and on March 2, AVO downgraded the Aviation Color Code and Volcano Alert Level to **GREEN/NORMAL**, where it remained for the rest of the year.

Retrospectively, the combination of satellite images, aerial photographs, and field inspection demonstrated that a brief explosive event from Kanaga’s summit had indeed occurred, modifying the summit crater and producing a very small tephra fall deposit. A March 5 satellite radar image clearly showed a new open fissure along the southern rim of the summit crater (fig. 25). The feature was about 600 m (1,970 ft) in length and continued a short distance down the upper western flank of the volcano. In places, the fissure was 15 m (50 ft) wide and white clouds of vapor issued from several points along the fissure. An additional fumarolic cloud issued from the 15-m-diameter (50-ft), circular hole in the bottom of the crater. On March 9, nearly 3 weeks after the explosion signal, no ejecta or ash fall deposits were noted in satellite images, however, additional snowfall and reworking on the steep flanks likely would have obscured any primary deposits. Given the transient nature of the event, the limited tephra fall, and residual steaming fissure, AVO concluded that this event was a sudden phreatic explosion originating in the shallow, hydrothermally active summit region of Kanaga. The orientation and location of the feature has no clear relationship to the 1993–1995 eruptive vent complex that involved effusion of lava and ash from both the summit crater and a fissure system on the upper eastern flank of the volcano (fig. 25, inset; fig. 26; Neal and others, 1995; Waythomas and others, 2002).

Notable plumes of white vapor from Kanaga’s summit were seen throughout the spring by ship and airborne observers as well as Adak residents. Ship-based observers on April 1 suggested that three distinct locations along the fissure were producing the most intense clouds. At least one satellite image on April 1 showed a possible plume from the summit. Bursts of seismicity were noted in mid- and late April. The seismic record was hampered by periods of noise and scattered data outages in late spring and early summer.

An AVO crew working via helicopter on the Kanaga seismic network in mid-June was able to describe the fissure and apparently new ash on the northern and eastern flanks; they were unable to land and inspect the volcano’s summit area, however, due to high winds. Steam was steadily rising from the summit fissure (fig. 27). On June 20, a faint sulfur odor was detected at the KINC seismic station located 2 km (1 mi) to the east of the volcano summit; our limited experience on the volcano makes it difficult to know how atypical this observation is from normal conditions. The team noted traces of what appeared to them to be recent ash on the northern flank down to an elevation of about 250 m (820 ft) ASL.

Aerial photographs by Roger Clifford in both summer and fall (figs. 28 and 29) provided excellent views of the summit fissure. Figure 29 shows a summer image of the nearly snow-free Kanaga cone; the fissure can be seen wrapping around and just outboard of the summit crater rim. The maximum opening across the fissure is about 15 m (50 ft) and white vapor issues from several point sources within the fissure. In November (fig. 29), Roger Clifford captured the western extent of the fissure where it crosses the summit and extends about 100 m (330 ft) down the western flank.

Brief episodes of elevated seismicity occurred during the rest of the year at Kanaga. On June 27, unusual, emergent seismic events were detected on records from the northern seismic stations of the Kanaga network. Periods of tremor also were noted. The significance of this seismicity with respect to the summit fissure or ongoing activity at Kanaga is unknown.

Satellite and seismic data from before February 18 was further analyzed to look for any changes prior to the explosion and opening of the summit fissure. A satellite image from January14, 2012, showed no structure in the area later cut by the fissure, although the southern rim was bare and lightly steaming. In October 2011, an unusual series of low frequency earthquakes had been noted, but any relationship of this to the 2012 activity remains unclear.

In response to this event, AVO established automated PUFF runs to simulate ash cloud trajectories in the event of a magmatic eruption, increased the frequency of daily satellite checks, and attempted limited field verification of events in conjunction with seismic network maintenance.

Kanaga Volcano is a symmetric stratocone (fig. 30) located on the northern end of Kanaga Island in the western Aleutian Islands, 33 km (21 mi) west of the community of Adak (fig. 1). Numerous eruptions have been recorded since the mid-1700s, the most recent began in 1993 and continued intermittently through most of 1995 (Neal and others, 1995; McGimsey and Neal, 1996). Active fumaroles persist in the summit region and hot springs occur near the base of the volcano. AVO installed a seismic network on Kanaga in 1999.

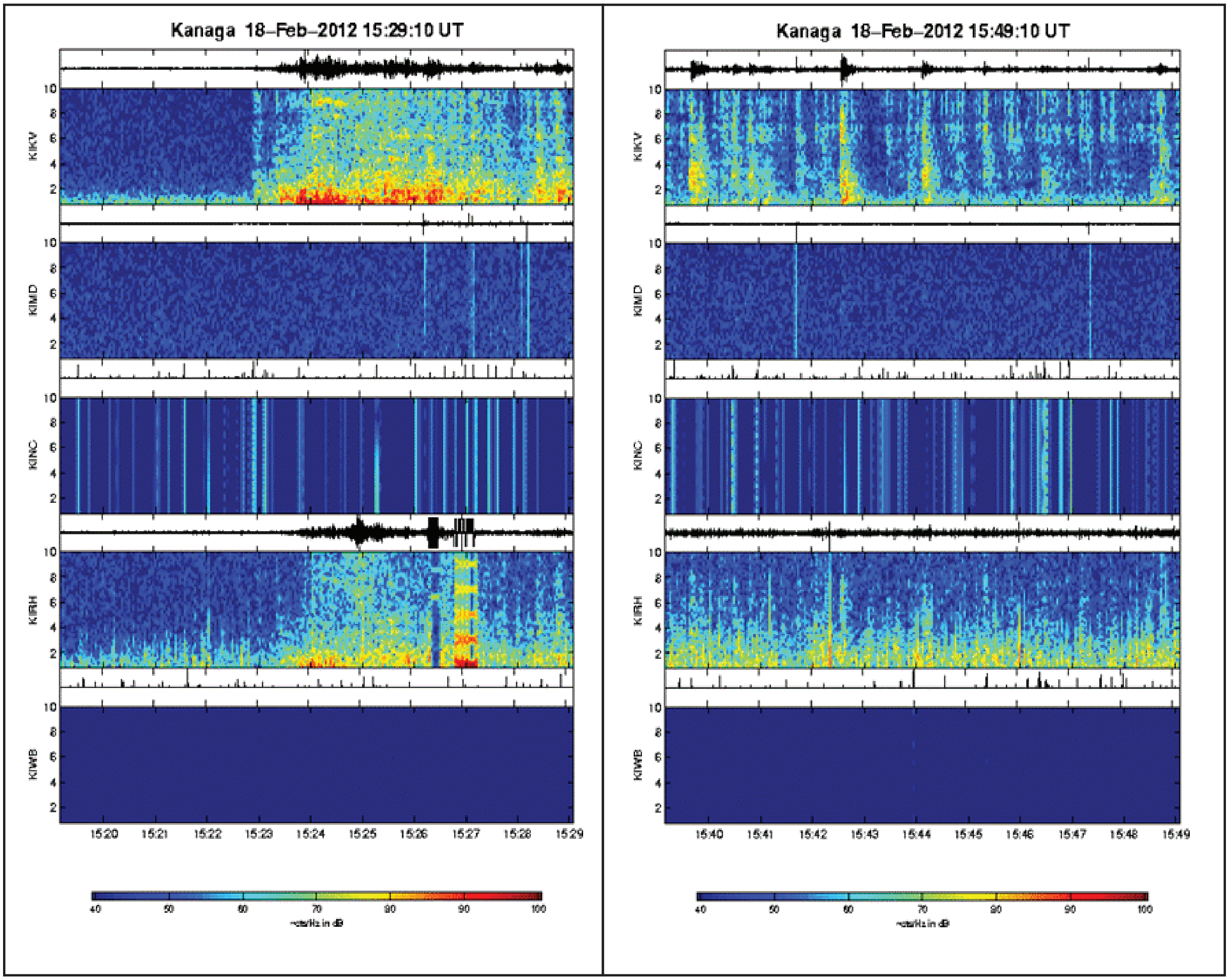

Figure 23. Spectrogram of tremor-like event on February 18, 2012, recorded on the Kanaga seismograph network. On KIRH, note the daily calibration signal at 15:27 UTC. Seismic stations KIMD, KINC, and KIWB were not operational at this time. Time is shown on the *x*-axis. Frequency is shown on the *y*-axis in Hz; warmer colors represent higher amounts of energy or signal strength.

Figure 24. Photograph of Kanaga from Adak Island, Alaska, on February 19, 2012. View is to the west. Photographs by M. Tillion, used with permission.

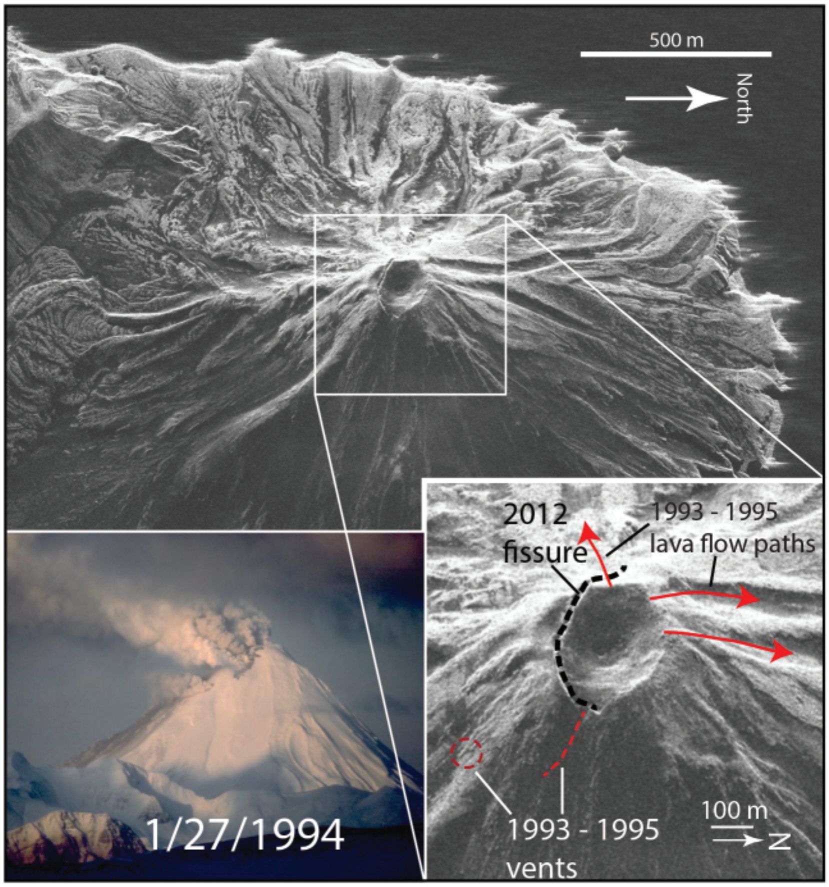

Figure 25. COSMOS SkyMed radar image of Kanaga collected March 5, 2012. The feature was not visible on images from October 2011. Inset at lower right shows schematic interpretation of the summit fissure with respect to the approximate location of some of the vents active during 1993–1995 (photograph inset at lower left). SAR image courtesy Zhong Lu, USGS/CVO and Dave Schneider, USGS/AVO.

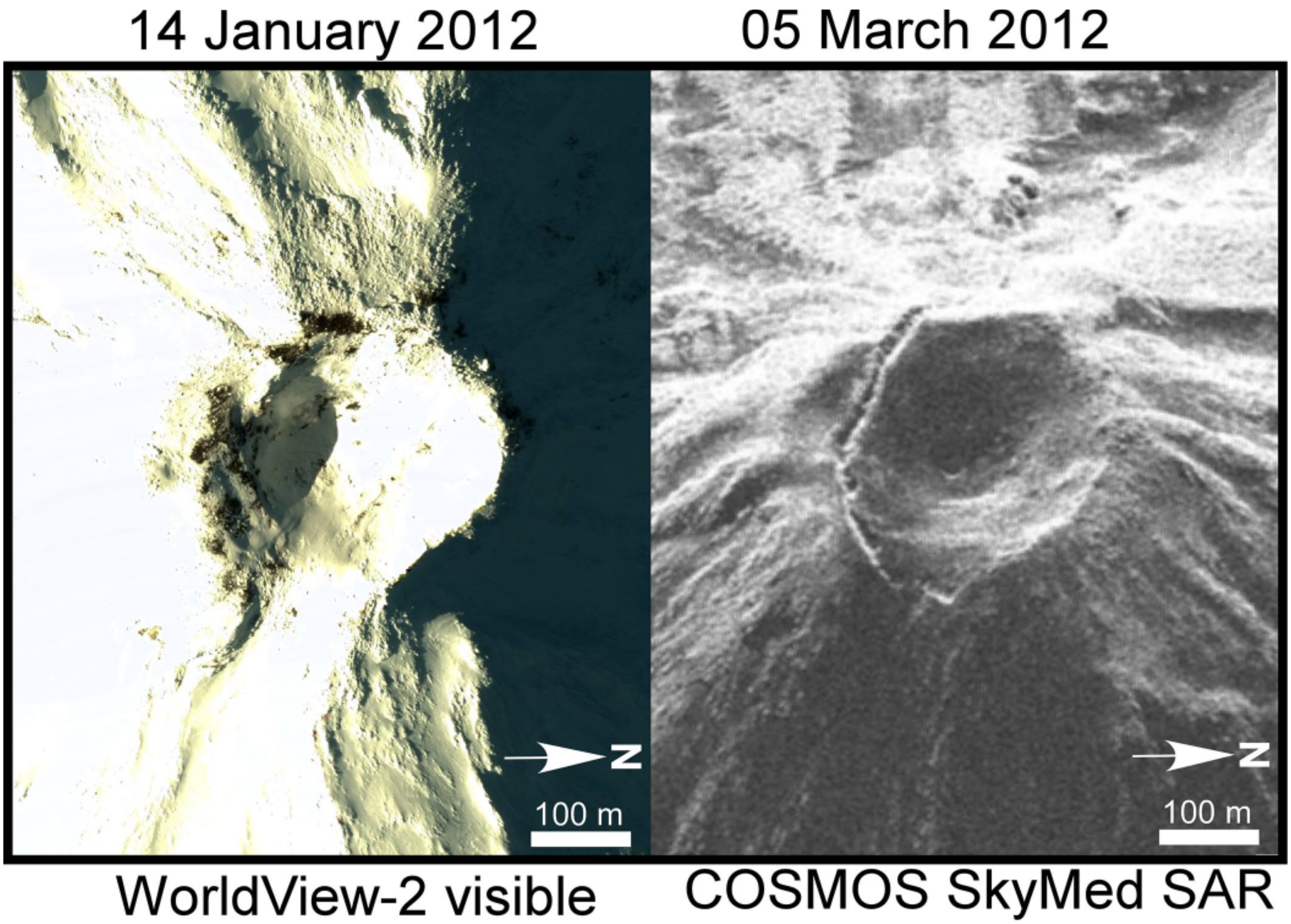

Figure 26. Identical satellite views of the summit crater of Kanaga Volcano spanning the timeframe of formation of the summit fissure. WorldView-2 view (left) on January 14, 2012, shows the summit crater with a few steaming fumaroles along the southern crater rim. COSMOS SkyMed SAR image (right) on March 5, 2012, shows the fissure extending along the southern edge of the crater. Images courtesy Rick Wessels, USGS/AVO.

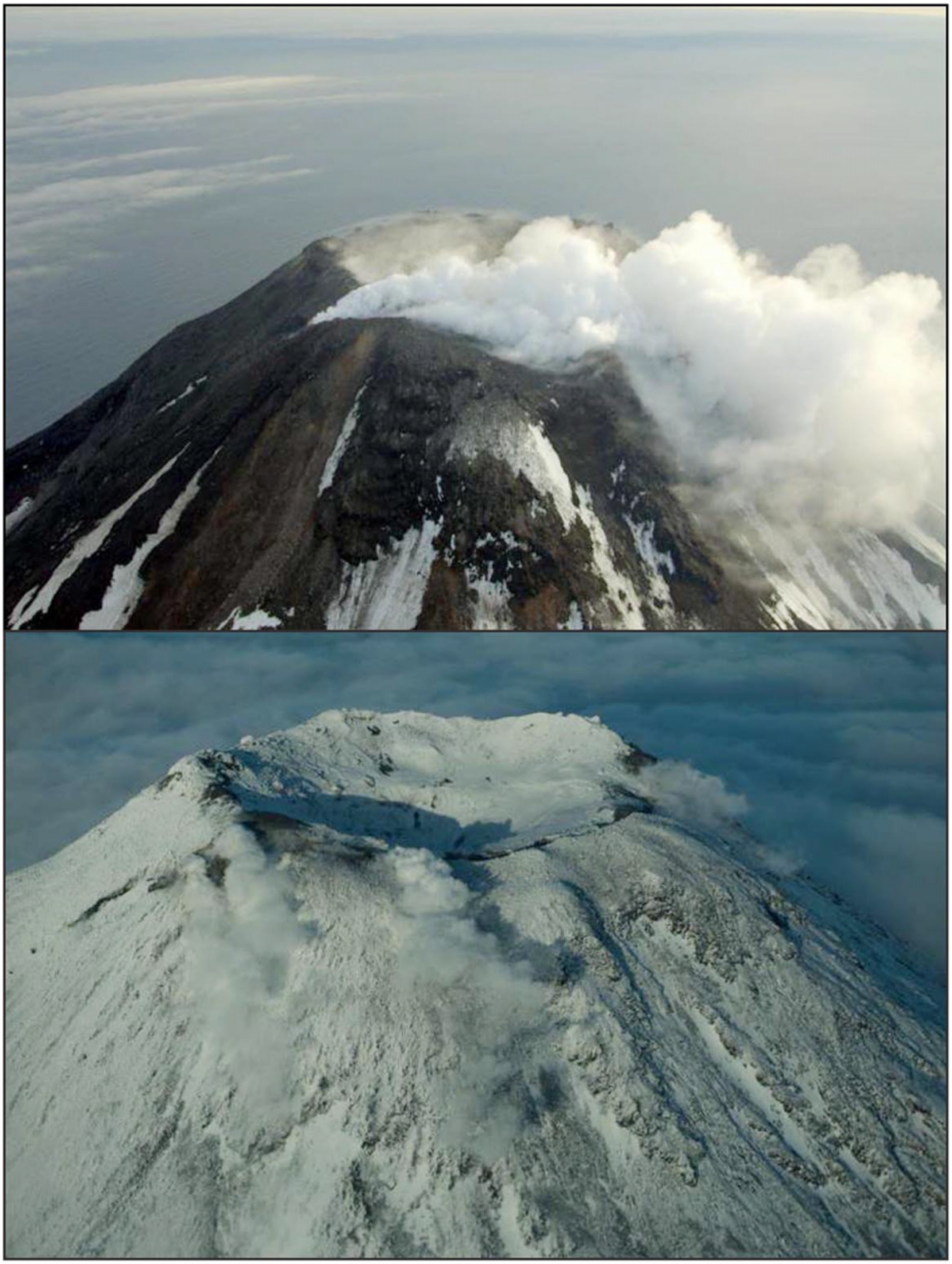

Figure 27. Oblique aerial views of Kanaga Volcano summit. North is at the top. In both images, a white vapor cloud billows from the 2012 fissure. Upper panel from June 25, 2012. Photograph by Cyrus Read, USGS/AVO. Bottom panel from November 2012, photograph by Roger Clifford, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=44101 (top) and http://www.avo.alaska.edu/images/image.php? id=47631 (bottom).

Figure 28. Oblique aerial view of Kanaga Volcano during the summer of 2012. Exact date uncertain. View is westward. Fissure is visible following the southern rim of the summit crater. Photograph by Roger Clifford, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=47561.

Figure 29. Oblique aerial view of the western rim of the Kanaga summit crater and upper western flank in November 2012. White vapor issues from the fissure that follows the southern summit crater rim and then extends about 100 m (330 ft) down the western flank. Photograph by Roger Clifford, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=47601.

Figure 30. Oblique aerial view of Kanaga Volcano. South is at the top. A white vapor cloud billows from the 2012 fissure. Photograph by Cyrus Read, USGS/AVO, June 25, 2012. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=44081.

Little Sitkin Volcano

GVP New # 311050

51°57'N 178°32'W
1,188 m (3,898 ft)

Little Sitkin Island

SEISMIC SWARMS, LIKELY MAGMATIC INTRUSION

Little Sitkin is a young, little known stratovolcano in the western Aleutian Islands. No historical eruptions have been verified or recorded in available records, but youthful-looking lava flows suggest fairly recent (potentially within the last few hundred years) effusive activity (Snyder, 1959; fig. 31). AVO installed a seismic network on Little Sitkin in 2005 and conducted brief reconnaissance of the geology of the volcano. Intermittent data transmission through the satellite uplink station on nearby Amchitka Island has kept this volcano off the formally monitored list. In 2012, AVO responded to a strong seismic swarm sequence and upgraded the Aviation Color Code and Volcano Alert Level temporarily to **YELLOW/ADVISORY.**

Seismic activity at Little Sitkin began to increase on August 22. Although volcano-tectonic earthquakes accounted for most of the seismicity, some unusual signals also were observed, most notably monochromatic earthquakes. A series of 5 monochromatic earthquakes that had unusually low resonant frequencies (0.6 Hz) that occurred during August 24–28. These earthquakes occurred at depths depths between 10 and 20 km (6-12 mi) and were recorded on seismic stations as far away as 80 km (50 mi) on Amchitka and Semisopochnoi Islands. These signals at Little Sitkin appear similar to that seen at Izu-Oshima Volcano in Japan (Ukawa and Ohtake, 1987). Two brief episodes of tremor also were recorded during this time.

On August 30, earthquake activity escalated dramatically (fig. 32), prompting AVO to upgrade the Aviation Color Code and Volcano Alert Level to **YELLOW/ADVISORY**. AVO instituted a heightened seismic watch schedule to examine seismic data every 2 hours. An RSAM alarm was established for Little Sitkin to alert seismologists in the event of a sudden escalation in seismicity. Frequent earthquakes continued through August 31, then decreased during the first few days of September. Of the 110 earthquakes located during the first week of September, epicenters averaged 3.5 km (2.2 mi) from the summit. After a short flurry of earthquakes on September 13, seismicity decreased, but remained well above background. On September 24, AVO reduced the frequency of seismic data checks to once every 6 hours.

Over the next 3 months, seismicity consisted of low-frequency tremor bursts with occasional brief swarms of VT events (fig. 33). Three notable flurries of seismicity occurred on October 13, 15, and 29. Another pulse of VT activity began on November 15 and continued through November 26. Six-hour seismic checks for Little Sitkin were discontinued on October 8.

On January 9, 2013, after more than a month of relative quiet and continued decrease in overall seismicity, AVO downgraded the Aviation Color Code and Volcano Alert Level to **GREEN/NORMAL**. (Note that prior to the onset of seismicity and upgrade to **YELLOW/ADVISORY** in August, the volcano had been designated **UNASSIGNED**. Technically, it should have returned to **UNASSIGNED**, but this did not happen until March 29, 2013).

Satellite images of the largest hot spring area west of the modern Little Sitkin cone (fig. 34) showed that no significant change had occurred in the area since the last observations in late-October and early-September 2012. AVO received no reports from mariners or air crews of any changes at the surface; however, this part of the Aleutian Arc receives few visitors throughout the year and minor changes in activity could well go unnoticed.

Subsequent analysis of InSAR results from images that span the time period of increased seismicity indicates 1–2 cm (0.4–0.8 in.) of inflation beneath the modern Little Sitkin cone. This result, along with the evolution of the seismic sequence in 2012, strongly suggests a magmatic intrusion as the source of observed seismicity and geodetic change (Haney and others, 2014).

The modern Little Sitkin cone sits within what has been interpreted as a nested, double caldera of probable late Pleistocene age (fig. 35; Snyder, 1959). Young, blocky lava flows from both the summit crater (fig. 36) and a fissure vent west of the cone suggest late Holocene and possibly historical activity, but geologic studies of this volcano are incomplete and no historical eruptions are considered confirmed. The summit crater and upper flanks of Little Sitkin cone are extensively hydrothermally altered and at least one high temperature acid hot spring on the western part of the island (fig. 34) attests to continued surface heat flux at the volcano (Snyder, 1959; Motyka and others, 1993). In 2005, AVO installed a seismic network on Little Sitkin; satellite telemetry of data from the uplink station on nearby Amchitka Island has been intermittent, thus AVO has not considered this volcano to be formally monitored. As a result, until the activity of 2012, the volcano had been at Volcano Activity Level **UNASSIGNED**.

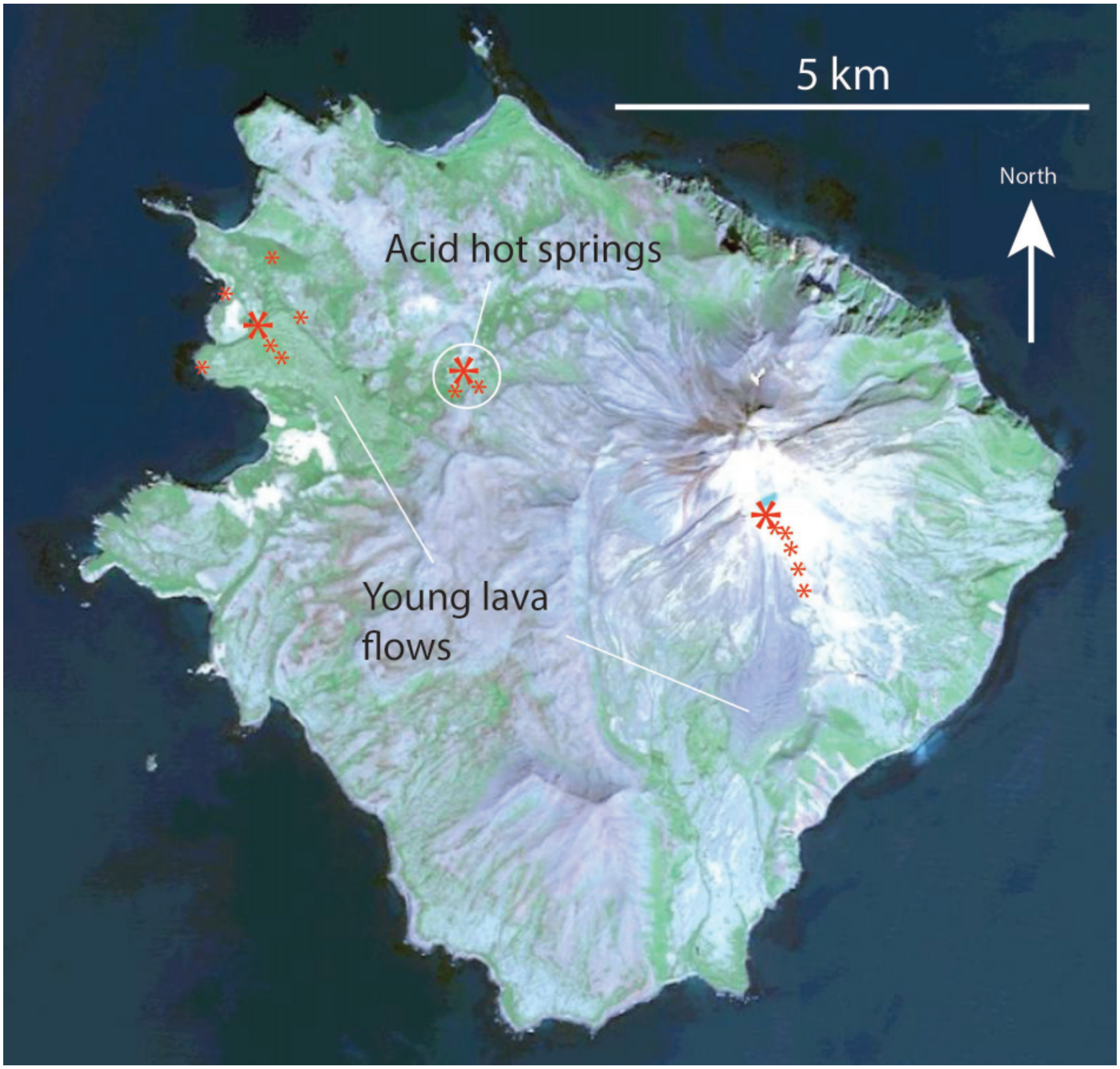

Figure 31. Worldview-2 satellite image of Little Sitkin Island. Youngest-appearing but undated lava flows are indicated. Fumarolic areas and hot springs (after Snyder, 1959) are shown by red asterisks; larger symbols are for major thermal areas. Circled area hosts acidic, boiling-point springs, pools, and mudpots. Image courtesy Digital Globe™. Date of image August 26, 2012.

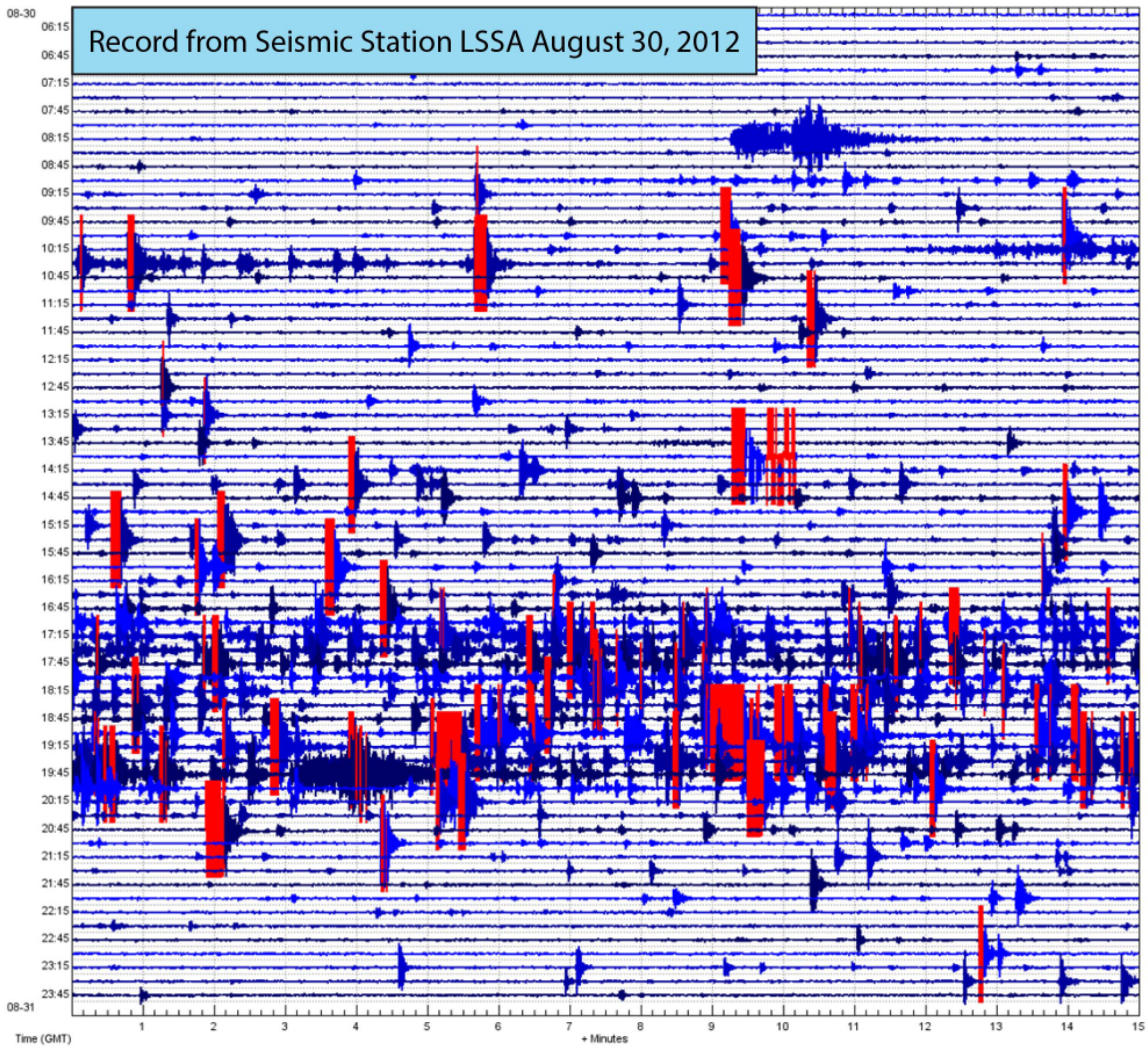

Figure 32. Helicorder record showing a swarm of primarily volcano-tectonic earthquakes at Little Sitkin volcano on August 30, 2012. Of the more than 60 locatable events during this swarm, most occurred between 4 and 10 km (2.5 and 6.2 mi) depth below sea level. Epicenters clustered in the northwestern quadrant of the island.

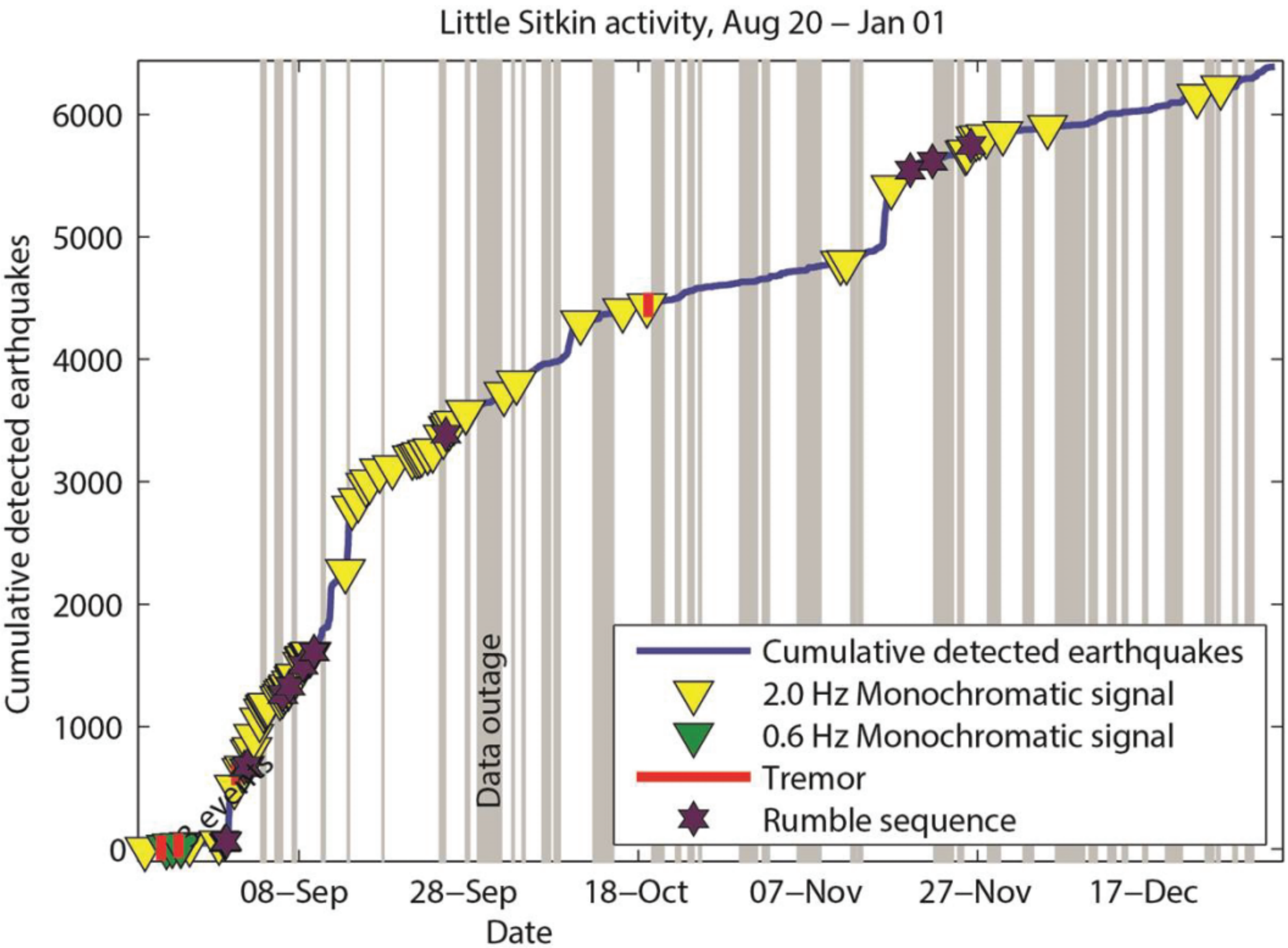

Figure 33. Graph showing preliminary summary of seismicity at Little Sitkin during the 2012 unrest. Cumulative curve reflects number of detected volcano-tectonic earthquakes. The 2.0- and 0.6-Hz monochromatic events indicated by inverted yellow and green triangles, respectively, are short-lived earthquakes with dominant low frequencies. Several periods of tremor lasting up to 10 minutes (red bars) were detected over the course of the unrest. "Rumble sequences" refer to series of closely spaced earthquakes over the course of 5–10 minutes that gradually increase in amplitude. Figure and analysis courtesy H. Buurman, UAFGI/AVO.

Figure 34. View of a portion of the main acid hot spring area, west Little Sitkin Island, September 28, 2005 (see fig. 31). Photograph by C. Neal, USGS/AVO on June 25, 2012.AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=4549. Inset shows a boiling pool, about 1 m (3.3 ft) across. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=4545.

Figure 35. Oblique aerial view, northeast is at the top, of Little Sitkin Island and the snow-capped modern volcanic cone. Photograph by Roger Clifford, November 2012, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php? id=47931.

Figure 36. Oblique aerial view of the summit of Little Sitkin volcano. North is at the top. Photograph by Roger Clifford, November 2012, used with permission. AVO database image at URL: http://www.avo.alaska.edu/images/image.php?id=47961.

Summary

2012 was a relatively quiet year in terms of eruptions and unrest for the Alaska Volcano Observatory. Confirmed eruptive activity was relatively minor and occurred at persistently active Mount Cleveland in the central Aleutians and Kanaga in the western Aleutians. Other volcanoes in Alaska provided minor unrest in the form of seismicity above background levels, seismic swarms possibly related to intrusions, and noticeable fumarolic emissions.

Acknowledgments

This report represents contributions of the entire Alaska Volcano Observatory staff, colleagues from other USGS Volcano Observatories, cooperating State and Federal agencies, and members of the public. We gratefully acknowledge all their work and participation in the mission of AVO. Thoughtful technical reviews by Helena Buurman and Cheryl Searcy improved the content and presentation.

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Glossary of Selected Terms and Acronyms

ADGGS Alaska Division of Geological & Geophysical Surveys. http://www.dggs.alaska.gov/.

AKDT "Alaska Daylight Time"; UTC-8 hours.

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

andesite volcanic rock composed of about 53–63 percent silica (SiO_2, 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.

ASTER Advanced Spaceborne Thermal Emission and Reflection Radiometer. http://asterweb.jpl.nasa.gov/.

AVHRR "Advanced Very High Resolution Radiometer"; AVHRR provides one form of satellite imagery. http://noaasis.noaa.gov/NOAASIS/ml/avhrr.html.

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.

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

CAVW Smithsonian Institute's "Catalog of Active Volcanoes of the World" (Siebert and others, 2010).

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

COSPEC "Correlation Spectrometer," a device for optically and remotely measuring sulfur-dioxide emissions.

ERSDAC Earth Remote Sensing Data Analysis Center. http://www.eoportal.org/.

FAA Federal Aviation Administration. http://www.faa.gov.

fallout a general term for debris which 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 which commonly produces lava fountains and flows.

FLIR "Forward Looking Infrared Radiometer," used to delineate objects of different temperature.

F/V Fishing Vessel.

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

GMS Geostationary Meteorological Satellite.

GMT Greenwich Mean Time.

GOES Geostationary Operational Environmental Satellite. http://www.goes.noaa.gov.

GPS Global Positioning System.

GSFC Goddard Space Flight Center. http://www.nasa.gov/centers/goddard/home.

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

HRPT High Resolution Picture Transmission.

IMGG Russian "Institute of Marine Geology and Geophysics." http://www.imgg.ru/.

InSAR Interferometric Synthetic Aperture Radar.

intracaldera refers to something within the caldera.

ISS International Space Station.

IVS Russian "Institute of Volcanology and Seismology."

JAROS Japan Resources Observation System Organization. http://www.jspacesystems.or.jp/.

JMA Japanese Meteorological Agency. http://www.jma.go.jp/jma.

Ka thousands of years before the present.

KDT "Kamchatkan Daylight Time" equals AKDT + 21 hrs.

KBGS Kamchatka Branch of Geophysical Surveys. http://www.emsd.ru/.

KEMSD Russian "Kamchatka Experimental and Methodical Seismological Department."

KST "Kamchatka Standard Time" equals AKST + 21 hours.

KVERT Kamchatka Volcanic Eruption Response Team. http://www.kscnet.ru/ivs/kvert/index_eng.php.

lapilli pyroclasts or volcanic fragments that are between 2 mm and 64 mm in diameter.

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

magma molten rock below the surface of the Earth.

METI Japanese Ministry of Economy, Trade, and Industry.

MODIS Satellite-based "Moderate-resolution Imaging Spectroradiometer." http://modis.gsfc.nasa.gov/.

NASA National Aeronautics and Space Administration. http://www.nasa.gov/.

NOAA National Oceanic and Atmospheric Administration. http://www.noaa.gov/.

NWS National Weather Service. http://www.weather.gov/.

OMI Ozone Mapping Instrument on NASA's Aura satellite. http://so2.gsfc.nasa.gov/.

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.

Pleistocene geologic epoch extending from about 2.6 million years ago to approximately 10,000 years before present.

PUFF a volcanic ash tracking model (Searcy and others, 1998).

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.

SAR Synthetic Aperture Radar.

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

seismic swarm a flurry of earthquakes; often precedes an eruption.

shield volcano a broad, gently sloping volcano usually composed of fluid, lava flows of basalt composition (for example, Mauna Loa, Hawaii).

SI International System of Units.

SIGMET SIGnificant METeorological information statement, issued by NWS.

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. http://www.imgg.ru/?id_d=659.

SWIR Short Wave Infrared.

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

TFR "Temporary Flight Restriction," issued by FAA.

TIR Thermal Infrared.

UAFGI University of Alaska Fairbanks Geophysical Institute. http://www.gi.alaska.edu/.

UFWS United States Fish and Wildlife Service. http://www.fws.gov/.

USGS United States Geological Survey. http://www.usgs.gov/.

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

UUA Urgent pilot report.

VAAC Volcanic Ash Advisory Center. http://www.ssd.noaa.gov/VAAC/vaac.html.

VAA Volcanic Ash Advisory.

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

VNIR Very Near Infrared.

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.

Vulcanian style of explosive eruption consisting of repeated, violent ejection of incandescent fragments of viscous lava, usually in the form of blocks, along with volcanic ash. Sometimes, Vulcanian eruptions involve water mixing with erupting magma.

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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