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

2005 Volcanic Activity in Alaska, Kamchatka, and the Kurile Islands: Summary of Events and Response of the Alaska Volcano Observatory

Scientific Investigations Report 2007–5269

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

Cover: Southeast flank of Augustine Volcano showing summit steaming, superheated fumarole jet, and ash dusting on snow. View is toward the northwest with Iniskin Bay in the distance. Photograph taken by Chris Waythomas, AVO/USGS, December 20, 2005.

2005 Volcanic Activity in Alaska, Kamchatka, and the Kurile Islands: Summary of Events and Response of the Alaska Volcano Observatory

By R.G. McGimsey, C.A. Neal, J.P. Dixon, U.S. Geological Survey, and Sergey Ushakov, Institute of Volcanology and Seismology

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

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Conversion Factors and Datums

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)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
foot (ft)	0.3048	meter (m)
gallon per minute (gal/min)	.06309	liters per second (L/sec)
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer (km)
ton, short (2,000 lb)	0.9072	megagram (Mg)
ton, long (2,240 lb)	1.016	megagram (Mg)
ton per day (ton/d)	0.9072	metric ton per day
ton per day (ton/d)	0.9072	megagram per day (Mg/d)

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)
cubic meter (m^3)	1.308	cubic yard (yd^3)
kilometer (km)	0.6214	mile (mi)
liter per minute (L/min)	15.85	gallon per minute (gal/min)
meter (m)	3.281	foot (ft)
metric ton per day	1.102	short tons per day
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×°C)+32.

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

2005 Volcanic Activity in Alaska, Kamchatka, and the Kurile Islands: Summary of Events and Response of the Alaska Volcano Observatory

By Robert G. McGimsey[1], Christina A. Neal[1], James P. Dixon[2], and Sergey Ushakov[3]

Abstract

The Alaska Volcano Observatory (AVO) responded to eruptive activity or suspected volcanic activity at or near 16 volcanoes in Alaska during 2005, including the high profile precursory activity associated with the 2005–06 eruption of Augustine Volcano. AVO continues to participate in distributing information about eruptive activity on the Kamchatka Peninsula, Russia, and in the Kurile Islands of the Russian Far East, in conjunction with the Kamchatkan Volcanic Eruption Response Team (KVERT) and the Sakhalin Volcanic Eruption Response Team (SVERT), respectively. In 2005, AVO helped broadcast alerts about activity at 8 Russian volcanoes. The most serious hazard posed from volcanic eruptions in Alaska, Kamchatka, or the Kurile Islands is the placement of ash into the atmosphere at altitudes traversed by jet aircraft along the North Pacific and Russian Trans East air routes. AVO, KVERT, and SVERT work collaboratively with the National Weather Service, Federal Aviation Administration, and the Volcanic Ash Advisory Centers to provide timely warnings of volcanic eruptions and the production and movement of ash clouds.

Introduction

The Alaska Volcano Observatory (AVO) monitors more than 40 historically active volcanoes of the Aleutian Arc (fig. 1). As of December 31, 2005, 30 of these are instrumented with seismometers to track earthquake activity, and background levels of activity have been defined (fig. 2; table 1). AVO's routine monitoring program also includes daily analysis of satellite imagery, occasional overflights, and compilation of pilot reports and observations of local residents and mariners. Additionally, AVO receives real-time deformation data from permanent Global Positioning System (GPS) stations at four Alaskan volcanoes (Okmok, Augustine, Akutan, and Mount Spurr).

Although 2005 began volcanologically quiet in Alaska—continuing a trend of little volcanic unrest that has persisted for several years—AVO responded to eruptive activity or suspected volcanic activity at or near 16 volcanoes, including the high profile precursory activity associated with the 2005–06 eruption of Augustine Volcano (fig. 1; tables 2 and 3): Spurr, Iliamna, Augustine, Martin, Mageik, Trident, Chiginagak, Aniakchak, Veniaminof, Pavlof, Hague, Shishaldin, Cleveland, Korovin, Kasatochi, and Tanaga.

As part of a formal agreement between AVO and several scientific institutes in Petropavlovsk-Kamchatsky, Russia, AVO continues to help distribute information on behalf of the Kamchatkan Volcanic Eruption Response Team (KVERT; Kirianov and others, 2002). Additionally, a newly established eruption response team, tracking activity in the Kurile Islands of the Russian Trans East, is in the beginning stages of collaborative work with AVO and KVERT to develop warning communication protocols (Rybin and others, 2004). In 2005, AVO assisted in broadcasting alerts about activity at eight volcanoes in Russia—Sheveluch, Klyuchevskoy, Bezymianny, Karymsky, Avachinsky, Mutnovsky, Ebeko, and Chikurachki (table 4).

The most serious hazard posed from volcanic eruptions in Alaska, Kamchatka, or the Kurile Islands is the placement of ash into the atmosphere at altitudes flown by jet aircraft, particularly along the North Pacific and Russian Trans East air routes (fig. 3). More than 100 historically active, ash-producing volcanoes lie beneath this corridor.

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[2] USGS Alaska Volcano Observatory, Alaska Science Center 903 Koyukuk Drive, AK 99775-7320.

[3] Kamchatka Volcanic Eruptions Response Team, Institute of Volcanology and Seismology, Piip Blvd., 9 Petropavlovsk-Kamchatsky, 683006, Russia.

1. *Bona-Churchill*
2. Wrangell
3. *Hayes*
4. Spurr
5. Redoubt
6. Iliamna
7. Augustine
8. *Snowy*
9. *Griggs*
10. Katmai
11. Novarupta
12. Trident
13. Mageik
14. Martin
15. Peulik
16. Ukinrek
17. Chiginagak
18. Aniakchak
19. Veniaminof
20. Pavlof
21. Dutton
22. *Isanotski*
23. Shishaldin
24. Fisher
25. Westdahl
26. Akutan
27. Makushin
28. Bogoslof
29. Okmok
30. Vsevidof
31. Kagamil
32. Carlisle
33. Cleveland
34. Yunaska
35. Amukta
36. Seguam
37. Korovin
38. Kasatochi
39. Great Sitkin
40. Kanaga
41. Tanaga
42. Gareloi
43. Semisopochnoi
44. Little Sitkin
45. Kiska

Hague*

* Hague is a satellite vent within Emmons Lake Caldera. It is not seismically monitored and not considered "historically active," although it has frequent hydrothermal activity.

Figure 1. Location of historically active volcanoes in Alaska and place names used in this summary. Volcanoes with no documented significant historical unrest but still considered hazardous based on late-Holocene eruptive activity are italicized. Volcanoes mentioned in this report are in red.

This report summarizes volcanic activity in Alaska, Kamchatka, and the Kuriles in 2005 and describes AVO's operational response. Only those reports or inquiries that resulted in a "significant" investment of staff time and energy (arbitrarily defined as several hours or more for reaction, tracking, and follow-up) are included. Where more extensive published documentation for an episode of unrest exists, we provide full references. Additionally, AVO typically receives dozens of reports of steaming, unusual cloud sightings, or false eruption reports throughout the year. Most of these are resolved quickly and are not tabulated here as part of the response record. We use the phrase "suspect volcanic activity" (SVA) to characterize unusual activity that requires staff response and is subsequently determined to be normal or enhanced fumarolic activity, weather-related phenomena, or other non-volcanic event (table 3).

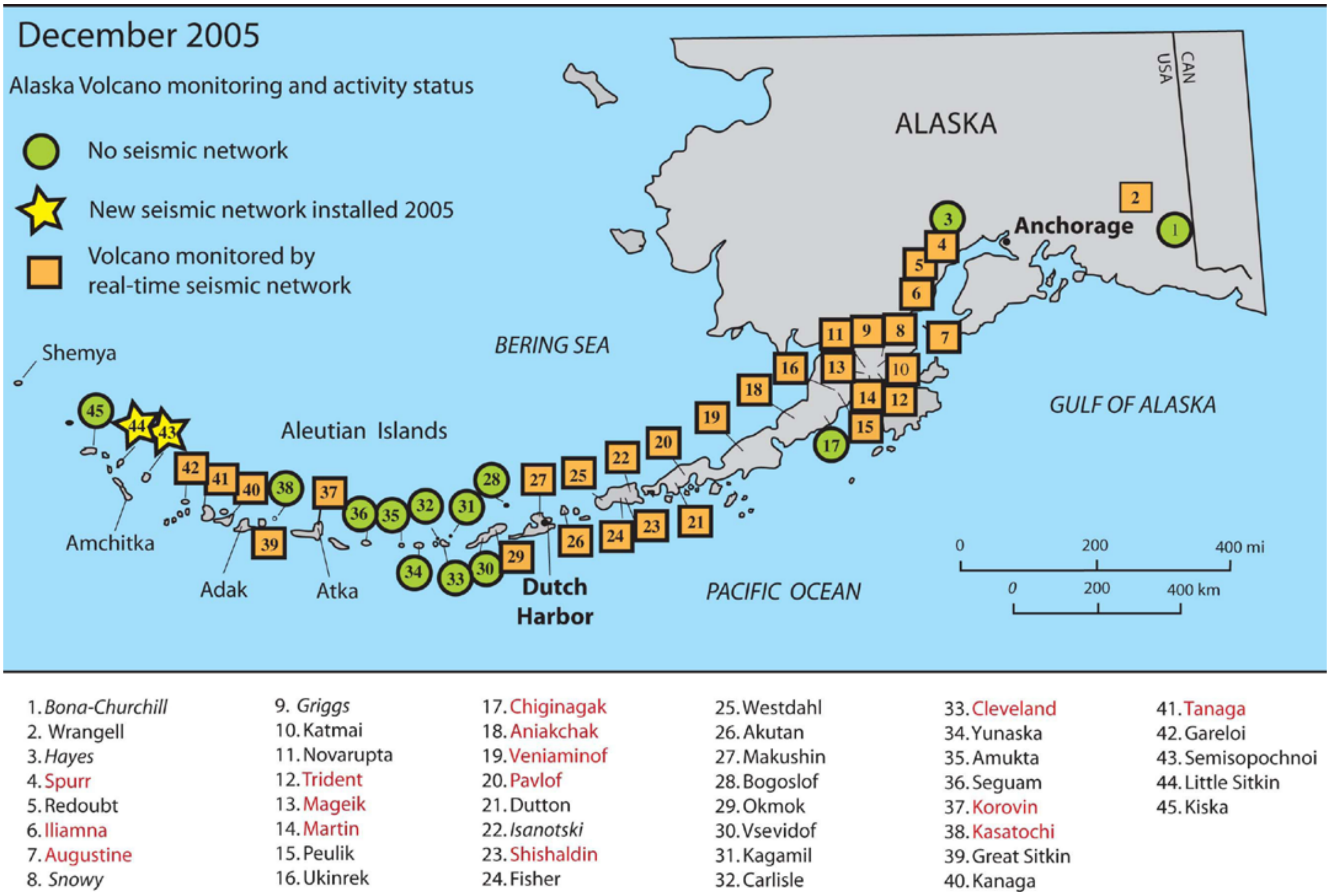


Figure 2. Seismically monitored Alaskan volcanoes as of December 31, 2005. Volcanoes with no documented significant historical unrest but still considered hazardous based on late-Holocene eruptive activity are italicized. Volcanoes mentioned in this report are shown in red.

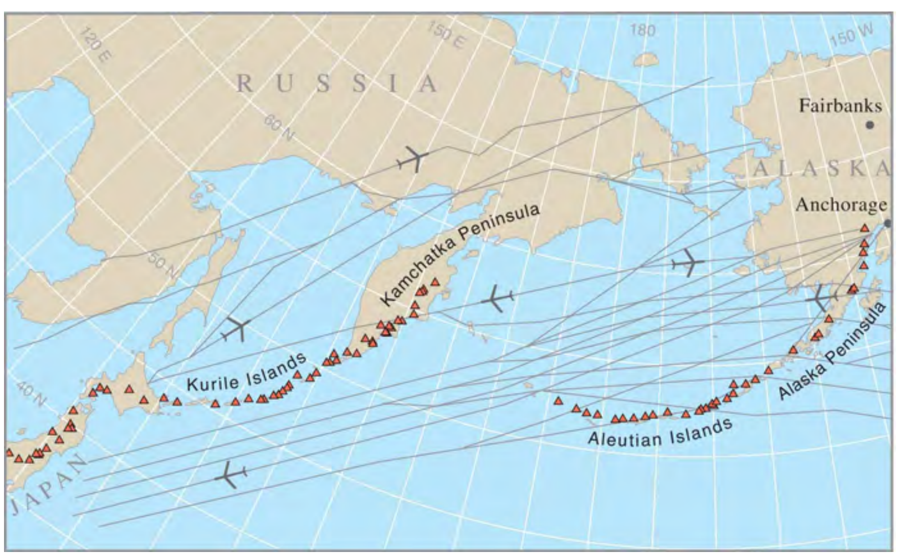


Figure 3. Location of Russian and Alaskan volcanoes and their proximity to North Pacific and Russian Trans East air routes.

Table 1. History of seismic monitoring of Alaskan volcanoes from August 1971 through December 31, 2005.

[History of seismic monitoring compiled by J. Dixon, U.S. Geological Survey (2006). "First station installed" is defined as the receipt of 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 wait several months to understand background rates of seismicity before declaring a volcano seismically monitored. We note here the first mention of the seismic status of each monitored volcano in the AVO weekly update. These written information statements began during the Redoubt eruption in 1989–90 and first mentioned all Cook Inlet volcanoes in April 1991. Magnitude of completeness is the lowest magnitude that can confidently be located. n/a, not applicable]

Volcano	Approximate start date of seismic monitoring	Magnitude of completeness
Wrangell	First station installed – July 2000 Network finished (Min 4 stations) – ***August 2001*** Added to monitored list – November 2001	0.7
Spurr	First station installed – August 1971 Network finished (Min 4 stations) – ***August 1989*** Added to monitored list – May 1994[1]	.2
Redoubt	First station installed – August 1971 Network finished (Min 4 stations) – ***August 1988*** Added to monitored list – May 1994[1]	.1
Iliamna	First station installed – September 1987 Network finished (Min 4 stations) – ***September 1994*** Added to monitored list – May 1994[1]	-.4
Augustine	First station installed – October 1976 Network finished (Min 4 stations) – ***August 1978*** Added to monitored list – May 1994[1]	-.9
Katmai-North (Snowy)	First station installed – August 1988 Network finished (Min 4 stations) – ***October 1998*** Added to monitored list – December 1998	.6
Katmai-Central (Griggs, Katmai, Novarupta, Trident)	First station installed – August 1988 Network finished (Min 4 stations) – ***July 1991*** Added to monitored list – November 1996	.6
Katmai-South (Martin, Mageik)	First station installed – August 1988 Network finished (Min 4 stations) – ***July 1996*** Added to monitored list – November 1996	.6
Peulik and Ukinrek Maars	First station installed – August 2004 Network finished (Min 4 stations) – ***August 2004*** Peulik added to list – December 2005 Ukinrek Maars added – April 2005	.8
Aniakchak	First station installed – July 1997 Network finished (Min 4 stations) – ***July 1997*** Added to monitored list – November 1997	1.0
Veniaminof	First station installed – February 2002 Network finished (Min 4 stations) – ***February 2002*** Added to monitored list – September 2002	1.1
Pavlof	First station installed – July 1996 Network finished (Min 4 stations) – ***July 1996*** Added to monitored list – November 1996	1.5
Dutton	First station installed – July 1988 Network finished (Min 4 stations) – ***July 1996*** Added to monitored list – November 1996	n/a

Table 1. History of seismic monitoring of Alaskan volcanoes from August 1971 through December 31, 2005.—Continued

[History of seismic monitoring compiled by J. Dixon, U.S. Geological Survey (2006). "First station installed" is defined as the receipt of 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 wait several months to understand background rates of seismicity before declaring a volcano seismically monitored. We note here the first mention of the seismic status of each monitored volcano in the AVO weekly update. These written information statements began during the Redoubt eruption in 1989–90 and first mentioned all Cook Inlet volcanoes in April 1991. Magnitude of completeness is the lowest magnitude that can confidently be located. n/a, not applicable]

Volcano	Approximate start date of seismic monitoring	Magnitude of completeness
Shishaldin (and Isantoski)	First station installed – July 1997 Network finished (Min 4 stations) – ***July 1997*** Isantoski added to list – December 1998 Shishaldin added to list – November 1997	0.9
Westdahl (Fisher)	First station installed – August 1998 Network finished (Min 4 stations) – ***October 1998*** Added to monitored list – December 1998	.9
Akutan	First station installed – March 1996 Network finished (Min 4 stations) – ***July 1996*** Added to monitored list – November 1996	.3
Makushin	First station installed – July 1996 Network finished (Min 4 stations) – ***July 1996*** Added to monitored list – November 1996	.6
Okmok	First station installed – January 2003 Network finished (Min 4 stations) – ***January 2003*** Added to monitored list – January 2004	.9
Korovin	First station installed – July 2004 Network finished (Min 4 stations) – ***July 2004*** Added to monitored list – December 2005	.7
Great Sitkin	First station installed – September 1999 Network finished (Min 4 stations) – ***September 1999*** Added to monitored list – December 1999	.3
Kanaga	First station installed – September 1999 Network finished (Min 4 stations) – ***September 1999*** Added to monitored list – December 2000	.9
Tanaga	First station installed – August 2003 Network finished (Min 4 stations) – ***August 2003*** Added to monitored list – June 2004	1.0
Gareloi	First station installed – August 2003 Network finished (Min 4 stations) – ***September 2003*** Added to monitored list – June 2004	1.0
Semisopochnoi	First station installed – September 2005 Network finished (Min 4 stations) – ***September 2005*** Added to monitored list – not added	n/a
Little Sitkin	First station installed – September 2005 Network finished (Min 4 stations) – ***September 2005*** Added to monitored list – not added	n/a

Table 2. Summary of 2005 VOLCANIC ACTIVITY in Alaska, including actual eruptions, possible eruptions, and unusual increases in seismicity or fumarolic activity.

[Location of volcanoes shown in figure 1. Description of Level of Concern Color Codes is shown in table 5]

Volcano	Date of activity	Type of activity
Mount Spurr	All of 2005	Continuation of increased seismicity, gas and heat flux to the summit; further development of ice cauldron, lake level declines following flowage event; temperatures of lake and adjacent wall rock increases; Color Code at **YELLOW** for all of 2005.
Augustine	May–December 2005	Significant increase in seismicity, deformation, and gas emission; beginning of the December 2005–March 2006 eruption.
Chiginagak	November 2004 to May 2005	Summit ice cap melts producing large cauldron; acidic lake partially drains adversely affecting streams, lake, fish, and plants for more than 30 kilometers (about 20 miles) down Indecision Creek drainage.
Veniaminof	All of 2005	Intermittent, small ash and steam plumes from intracaldera cone; Color Code changes eight times.
Cleveland	Late June to mid-August 2005	Upper flanks dusted with ash, thermal anomalies.
	October 7, 2005	Small ash cloud drifting east-southeast.
Korovin	February 24, 2005	Phreatic eruption produces large steam cloud and minor ash that fell locally on volcano.

Table 3. Summary of SUSPECT VOLCANIC ACTIVITY (SVA) in 2005.

[SVA is defined as a report of eruption or possible eruption that is determined to be normal fumarolic activity or non-volcanic phenomena, such as weather related. Localities shown in figure 1. Description of Level of Concern Color Codes is shown in table 5. PIREP, pilot weather report; VTTS, Valley of Ten Thousand Smokes]

Volcano	Date of activity	Type of activity
Iliamna	May 15, 2005	Large rock avalanche on southeast flank of South Twin produces distinctive seismicity.
Katmai Group (Martin, Mageik, and Trident)	February 26, 2005; June 2005;	PIREP of steam cloud (Martin or Mageik); possible new crater observed at Trident.
	November 3–10, 2005	High winds re-suspend VTTS ash forming a cloud over Kodiak Island.
Aniakchak	December 2004 to early February 2005	Unusual seismicity, thermal anomaly, intracaldera lake partially ice-free in winter.
Pavlof and Mount Hague	April 16, May 23–24, 2005	Minor steam plumes, possibly with ashes at Hague; mistakenly attributed to Pavlof.
Shishaldin	Mid-November and December 2005	Increase in seismicity and PIREP of anomalous steam plume.
Cleveland	March 13, April 27, 2005	3-pixel thermal anomaly in satellite image; PIREP of eruptive activity; no eruptive activity observed in satellite images or seismic data.
Kasatochi	July 2005	Field crew notes anomalous bubbling and floating scum on crater lake.
Tanaga	October 2005	Sudden increase in seismicity, followed by tremor; Color Code raised to **YELLOW** for about 6 weeks.

Table 4. Summary of VOLCANIC ACTIVITY on Kamchatka Peninsula and the Kurile Islands, Russia, 2005.

[Location of volcanoes shown in figure 1]

Volcano	Date of activity	Type of activity
Sheveluch	Intermittently throughout the year	Lava dome growth, repeated ash explosions, pyroclastic flows, ash plumes, ash falls.
Klyuchevskoy	January through November	Strombolian eruption, lava flows, lahars.
Bezymianny	Intermittently throughout the year	Continued dome growth with two brief explosive episodes.
Karymsky	Intermittently throughout the year	Strombolian, Vulcanian eruption continues; ash fall, lava extrusion, avalanches, degassing.
Avachinsky	November and December	Increased seismicity, thermal anomaly.
Mutnovsky	June 3-10	Increased fumarolic activity.
Ebeko	June 30–August 12; September 9–December 31	Increased fumarolic activity and phreatic explosions.
Chikurachki	March 13–May 6	Brief, mild explosive ash production.

The extent of AVO's response to volcanic activity in Alaska and the Russian East varies depending on the source, observation, and potential impacts. If our detection of unrest is based upon instrumental data (for example, from our seismic networks), evaluation of unrest occurs as rapidly as possible and, if warranted, communication protocols documented in the Alaska Interagency Plan for Volcanic Ash Episodes (Liebersbach and others, 2004) are initiated and monitoring efforts heightened. After receiving a second-hand report of activity at a non-instrumented volcano, AVO usually contacts the National Weather Service (NWS) and Federal Aviation Administration (FAA), AVO's operational partners in Russia, or local residents for corroboration and additional information. For verified, significant eruptive activity or volcanic unrest, an established call-down procedure is initiated to formally notify other government agencies, air carriers, facilities at risk, and the media. A special information release may be distributed if eruptive activity is confirmed. Events are summarized further in the AVO weekly update widely distributed each Friday by electronic mail and facsimile to various government agencies, scientists, airlines, the media, and members of the public. If an eruption or serious SVA is not confirmed, a notation is made in internal files.

AVO continues to issue daily "Current Status" reports for any Alaskan volcano in an elevated Level of Concern Color Code (for example, **YELLOW**, **ORANGE**, **RED**; tables 5 and 6). This procedure began on June 3, 2004, prompted by the needs of other government agencies for daily operational data to inform their staff of changes or the lack of significant change in the status of a hazardous volcano. Status reports are brief and sent by email to our weekly update distribution list and by fax to the NWS Center Weather Service Unit (CWSU) at Anchorage Air Route Traffic Control Center as well as to the Anchorage Volcanic Ash Advisory Center (VAAC). Reports also are posted automatically on the AVO public web page: http://www.avo.alaska.edu/activity/report_intro.php.

Summary information for 2005 is presented in geographical order from northeast to southwest along the Aleutian volcanic arc, Kamchatka, and the Kuriles. The Catalog of Active Volcanoes of the World (CAVW) numbers are provided for referencing the Smithsonian Institute files (Simkin and Siebert, 1994). All elevations reported are above sea level (ASL) unless noted, and time is reported as Alaska Standard Time (AST), Alaska Daylight Time (ADT), Hawaii-Aleutian Standard Time (HST), Kamchatkan Standard Time (KST), or Kamchatkan Daylight Time (KDT) [see glossary for distinction between Alaska and Kamchatka time]. We have chosen to preserve English units of measurements where they reflect the primary observations of distance or elevation such as those commonly received from pilot reports and aviation authorities in the United States. Elsewhere, measurements are presented in metric units with English units in parentheses or brackets. Information for Alaska volcanoes included here is compiled from AVO daily status reports (365), weekly updates (53), special information releases (20), internal bimonthly reports, AVO email and online logs, and the Smithsonian Institution Global Volcanism Network Bulletins that are available online: http://www.volcano.si.edu/reports/bulletin/index.cfm. For Russian volcanoes, AVO assisted KVERT in distributing 71 information releases.

Table 7 presents cross-referenced lists by year and by volcano for volcanic activity as reported in the 1992–2004 AVO annual summaries, as well as bibliographic references for the summary reports listed by year. In addition to standard citations, some references to previous volcanic activity contained in AVO annual summaries are cited in the text of this report as "table 7." Acronyms and geologic terms used in this report are explained in the glossary at the end of the report.

Table 5. Level of Concern Color Codes used by Alaska Volcano Observatory for volcanic activity in Alaska and Kamchatka, Russia.

[To more concisely describe the level of concern about possible or ongoing eruptive activity at an Alaskan volcano, the Alaska Volcano Observatory (AVO) uses the following color-coded classification system. Definitions of the colors reflect AVO's interpretations of the behavior of the volcano. Definitions are listed below followed by general descriptions of typical activity associated with each color]

Level of Concern Color Code: Generic	Definition and general description
GREEN	**No eruption anticipated.** Volcano is in quiet, "dormant" state.
YELLOW	**An eruption is possible in the next few weeks and may occur with little or no additional warning.** Small earthquakes detected locally and (or) increased levels of volcanic gas emissions.
ORANGE	**Explosive eruption is possible within a few days and may occur with little or no warning. Ash plume(s) not expected to reach 25,000 feet above sea level.** Increased numbers of local earthquakes. Extrusion of a lava dome or lava flows (non-explosive eruption) may be occurring.
RED	**Major explosive eruption expected within 24 hours. Large ash plume(s) expected to reach at least 25,000 feet above sea level.** Strong earthquake activity detected even at distant monitoring stations. Explosive eruption may be in progress.

A note on AVO's definition of "historically active volcanoes":

AVO defines an "active volcano" as a volcanic center that has had an eruption or a period of intense seismic, fumarolic, or deformation activity that is inferred to reflect magma at shallow levels within the volcano. The "historic" period in Alaska is considered post mid-1700s when written records of volcanic activity were first compiled and archived. We include some volcanoes on our list of 'potentially active' volcanoes that do not exactly fit this criteria because geologic evidence suggests that they have been active within the last few thousand years and, as such, although not historically active, they retain a potential for hazardous activity that requires careful monitoring. As our geologic understanding of Alaska's volcanoes improves with additional fieldwork and modern radiometric dating techniques, these lists undoubtedly will evolve.

Table 6. Alaskan volcanoes with Color Code changes in 2005.

[Description of Level of Concern Color Codes is shown in table 5. UA (unassigned): Volcanoes that do not have a real-time seismic network are not assigned a color code **GREEN** because without seismic data, AVO has no definitive information that the level of activity at the volcano is at background. Peulike/Ugashik, Ukinrek Maars, and Korovin volcanoes became "assigned" during 2005 as new seismic networks were deemed operable]

Color Code	Date of change
MOUNT SPURR	
YELLOW	January 1–December 31
AUGUSTINE	
GREEN	January 1–November 29
YELLOW	November 29–December 31
PEULIK/UGASHIK	
UA	January 1–April 29
GREEN	April 29–December 31
UKINREK MAARS	
UA	January 1–December 2
GREEN	December 2–December 31
VENIAMINOF	
GREEN	January 1-4
YELLOW	January 4-10
ORANGE	January 10–February 25
YELLOW	February 25–March 4
GREEN	March 4–September 7
YELLOW	September 7-28
GREEN	September 28–November 4
YELLOW	November 4–December 30
GREEN	December 30-31
CLEVELAND	
UA	January 1–July 7
YELLOW	July 7–August 27
UA	August 27–October 7
ORANGE	October 7-10
YELLOW	October 10–November 25
UA	November 25–December 31
KOROVIN	
UA	January 1–February 24
YELLOW	February 24–March 4
UA	March 4–December 2
GREEN	December 2-31
TANAGA	
GREEN	January 1–October 7
YELLOW	October 7–November 25
GREEN	November 25–December 31

Table 7A. Compilation by year of volcanoes included in an Alaska Volcano Observatory Annual Summary between 1992 and 2005.

[Prior to 1995, Alaska Volcano Observatory did not report on Russian volcanoes]

Year	Alaskan volcanoes mentioned	Russian volcanoes mentioned
1992	Spurr/Crater Peak	
	Iliamna	
	Redoubt	
	Mageik (Katmai Group)	
	Westdahl	
	Akutan	
	Bogoslof	
	Seguam	
1993	Churchill	
	Sanford	
	Spurr/Crater Peak	
	Veniaminof	
	Shishaldin	
	Makushin	
	Seguam/Pyre Peak	
	Kliuchef (Akta)	
	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
1998	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	
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	
	Unnamed source	
2004	Mt. Crillon (non-volcanic peak)	Sheveluch
	Mount Spurr	Klyuchevskoy
	Katmai Group (Martin)	Bezymianny
	Veniaminof	Karymsky
	Shishaldin	Chirinkotan (Kuriles)
	Westdahl	
2005	Augustine	Sheveluch
	Katmai Group (Martin, Mageik, Trident)	Klyuchevskoy
	Chiginagak	Bezymianny
	Aniakchak	Karymsky
	Veniaminof	Avachinsky
	Pavlof/Mt. Hague	Mutnovsky
	Shishaldin	Ebeko
	Cleveland	Chikurachki
	Korovin	
	Kasatochi	
	Tanaga	

Table 7*B*. Compilation by volcano for particular years included in an Alaska Volcano Observatory Annual Summary between 1992 and 2005.

[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
Sanford	1993	SVA, reported steam plume likely from avalanche
	1994	SVA, reported steam plume likely from avalanche
	1997	SVA, large steam cloud from southwest face
Shrub Mud	1997	Eruption; energetic ejection of saline mud and CO_2
	1998	Eruption continues; saline mud and CO_2 ejected
	1999	Eruption continues, saline mud and CO_2 emission
Spurr/Crater Peak	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
Redoubt	1992	SVA, steam plume from still-cooling dome
	2003	SVA, anomalous weather cloud
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
Augustine	1998	1986 dome spine partially collapses, generates mudflow
	2005	Precursory activity prior to eruption in early 2006
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 resuspended ash
Martin	2004	SVA, large steam plume
Martin/Mageik/Trident	2005	SVA, steam cloud, resuspended ash, new crater?
Becharof Lake	1998	SVA, intense seismic swarm and inflationary episode
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
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

Table 7*B*. Compilation by volcano included for particular years included in an Alaskan Volcano Observatory Annual Summary between 1992 and 2005.—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	
Kupreanof	1994	SVA, PIREP of unusual steam plume
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, mislocated steam 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
Westdahl	1992	Fissure eruption, lava fountains, ash clouds, lava flow
	1996	SVA, suspicious weather cloud on satellite image
	2004	SVA, seismic swarm
Akutan	1992	SVA, steam/ash emissions
	1996	Intensive seismicity, ground cracking
	1998	SVA, tremor-like seismicity
	2003	SVA, anomalous steam plume
Makushin	1993	Minor phreatic
	1994	SVA, PIREP of minor steam/ash
	1995	SVA, steam plume
	2001	SVA, increase in seismicity
Bogoslof	1992	Dome extrusion, ash and steam emissions
Okmok	1997	Strombolian eruption
	2001	SVA, seismic swarm
Vsevidof	1999	SVA, sighting of ash after regional earthquake
Cleveland	1994	SVA, possible steam/ash emission
	1997	Minor eruption, steam/ash
	2001	Eruption; gas/ash, lava/debris flows
	2005	SVA, possible minor eruptive activity
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 (Akta)	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
Kasatochi	2005	SVA, unusual bubbling; floating scum on crater lake
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

Table 7*B*. Compilation by volcano included for particular years included in an Alaska Volcano Observatory Annual Summary between 1992 and 2005.—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	
Tanaga	1996	Possible eruption and ash emission
	2005	SVA, anomalous seismicity, including a period of tremor
	Kamchatka and northern Kurile Islands (north to south)	
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
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
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
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 Stombolian eruptions, explosions, lava, ash fall
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
Alaid (Kurile Islands)	1996	Ash plume
	1997	SVA
Ebeko	2005	Increased fumarolic activity and phreatic eruptions
Chikurachki	2003	Strombolian and Vulcanian eruption, ash fall
	2005	Brief explosion produces ash and ash fall
Chirinkotan	2004	Brief, low-level steam, gas, and ash emission

Table 7*C*. Citations for Alaska Volcano Observatory annual summary reports, 1992–2004.

[N/A, not available]

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.	N/A
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 96-0024, 21 p.	http://geopubs.wr.usgs.gov/open-file/of96-24/
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 95-0271, 18 p.	http://geopubs.wr.usgs.gov/open-file/of95-271/
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 96-0738, 22 p.	http://geopubs.wr.usgs.gov/open-file/of96-738/
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 97-0433, 34 p.	http://geopubs.wr.usgs.gov/open-file/of97-433/
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 99-0448, 42 p.	http://geopubs.wr.usgs.gov/open-file/of99-448/
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 03-0423, 35 p.	http://pubs.usgs.gov/of/2003/of03-423/
1999	McGimsey, R.G., Neal, C.A., and Girina, Olga, 2004a, 1999 volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1033, 49 p	http://pubs.usgs.gov/of/2004/1033/
2000	Neal, C.A., McGimsey, R.G., and Chubarova, Olga, 2004, 2000 volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1034, 37 p.	http://pubs.usgs.gov/of/2004/1034/
2001	McGimsey, R.G., Neal, C.A., and Girina, Olga, 2004b, 2001 volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1453, 53 p.	http://pubs.usgs.gov/of/2004/1453/
2002	Neal, C.A., McGimsey, R.G., and Girina, Olga, 2005, 2002 volcanic activity in Alaska and Kamchatka: Summary of events and response of the Alaska Volcano Observatory: U.S. Geological Survey Open-File Report 2004-1058, 51 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, 58 p.	http://pubs.usgs.gov/of/2005/1310/
2004	Neal, C.A., McGimsey, R.G., Dixon, Jim, 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, 67 p.	http://pubs.usgs.gov/of/2005/1308/

Volcanic Activity in Alaska, Northeast to Southwest along Aleutian Arc

Mount Spurr Volcano

CAVW# 1103-04 [CAVW is the Smithsonian Institution Global Volcanism Program identifier from their Catalog of Active Volcanoes of the World]

61°18′N 152°15′ W
3,374 m (11,070 ft)

Cook Inlet

CONTINUATION OF INCREASED SEISMICITY, GAS AND HEAT FLUX TO THE SUMMIT OF MOUNT SPURR; FURTHER DEVELOPMENT OF ICE CAULDRON; LAKE LEVEL DECLINES FOLLOWING FLOWAGE EVENT.

During 2005, elevated seismicity continued beneath Mount Spurr, and the summit ice-collapse pit enlarged—becoming a large cauldron—as heat was supplied to the summit area. The lake changed in size, and the amount of ice debris on the lake varied. Lake level declined in May, seemingly associated with the generation of a small debris flow on the upper southeast flank. With the decline in water level, subaqueous fumaroles emerged and the area of hot, steaming wall rock increased. Temperatures of the warm zones measured with Forward-Looking Infrared Radiometer (FLIR) increased somewhat over the year. Emissions of CO_2 and SO_2 decreased. The Level of Concern Color Code for Mount Spurr remained at **YELLOW** for all of 2005 (table 6).

Background: The earliest signs of the recent unrest may have been a brief, shallow, earthquake swarm that occurred on October 20, 2002. This was followed in early July 2004 with a significant increase in volcano-tectonic and long-period earthquake activity (Power, 2004; Power and others, 2004) (fig. 4, table 8). A pilot weather report (PIREP) of unusual activity at Spurr on July 11, 2005, prompted an AVO observation flight on July 15, 2004, which discovered multiple dark debris flow lobes emanating primarily from point sources within the glacial ice cover on the east flank of the Mount Spurr summit, the top of which was enshrouded in clouds (McGimsey and others, 2004c; Neal and others, 2005b; Coombs and others, 2006). Several weeks later (August 2) on a second overflight, the existence of a newly formed, about 50 to 60 m (165 to 200 ft) diameter and 25 m (82 ft) deep, steep-walled collapse pit at the summit was confirmed. A small, ice-choked gray lake occupied the bottom of the pit. [Note that later acquisition and analysis of photographs and images taken in June and July show that the subsidence at the summit was visible by June 20 and that the ice pit is first visible on July 8, 2004 (see table 8)]. Thus, a prolonged period of gradual melting of a substantial portion of the ice- and snow-filled summit crater of Mount Spurr and development of a large ice cauldron began. The unrest is interpreted to result from a magmatic intrusion beneath the volcano that likely occurred in mid-2004 (Cervelli and others, 2005; Coombs and others, 2006).

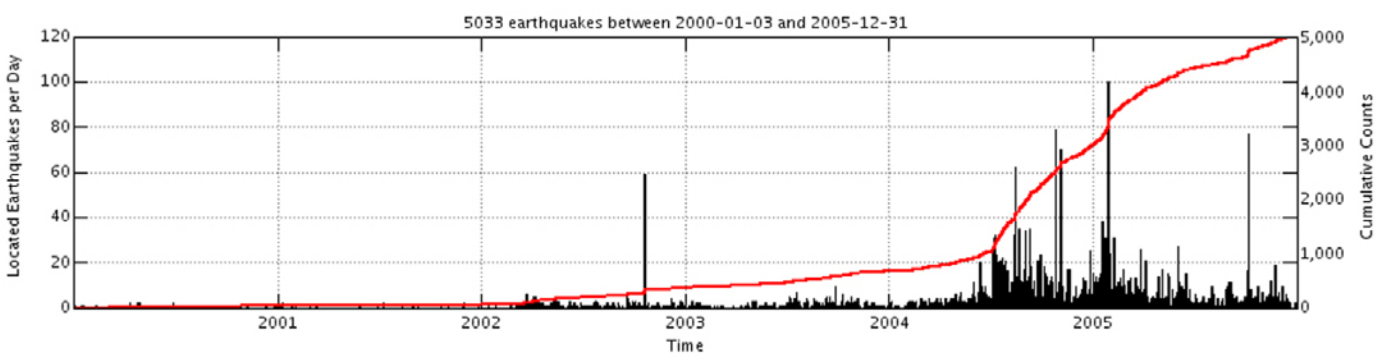


Figure 4. Seismicity beneath Mount Spurr from 2000 through 2005. A significant increase in seismicity at Spurr associated with the present activity began in July 2004. Red line denotes the cumulative total of located earthquakes over time. The subtle increase beginning in 2002 is owing to AVO changing earthquake acquisition systems, March 1, 2002 (Dixon and others, 2005). Courtesy of John Power, AVO/USGS.

Table 8. Chronology of events and observations relating to volcanic unrest at Mount Spurr, Alaska, 2004–05.

[Modified from Coombs and others (2006). AVO, Alaska Volcano Observatory; AST, Alaska Standard Time; ASTER, Advanced Spaceborne Thermal Emission and Reflection Radiometer; FLIR, Forward Looking Infrared Radiometer used to delineate objects of different temperature; m^2, square meter; –, no data]

Date	Observation	Source	Area of ice cauldron (m^2)
March 19, 2004	Climbers traverse area of future ice cauldron; no surface disturbance noted, steaming rock below the summit, audible gas emission, and strong H_2S reported.	Photograph by C. Arnold	–
May 3, 2004	Oblique aerial photograph of summit shows no deformation.	Photograph by S. Parks	–
June 20, 2004	Oblique aerial photograph shows development of subsidence in summit glacier.	Photograph by B. Hopper	–
July 8, 2004	Ice cauldron first visible; no open water.	ASTER image	4,250
July 10, 2004	Debris flows on the east-southeast flank of summit.	Landsat image	–
July 15, 2004	Overflight confirms debris-flow deposits on the east-southeast flank of Spurr summit. More flows visible than in July 10 satellite image suggesting at least two generations of debris flows.	AVO observation flight	–
August 2, 2004	~50-m-diameter ice cauldron with open water	AVO observation flight	–
August 4, 2004	Rock exposed in cauldron wall; dark sediment (tephra?) sloughing out of ice in walls; lake mostly covered by ice except for north edge.	AVO observation flight	–
August 10, 2004	Size of cauldron, 65 by 95 meters	QuickBird image	5,270
August 12, 2004	Warm rock visible along shoreline of ice-cauldron lake.	AVO FLIR flight	–
September 4, 2004	Steaming from long-lived hole in glacier downslope and to the south-southeast of ice cauldron.	AVO observation flight	–
September 23, 2004	Size of cauldron, 95 by 120 meters; south half of lake ice-covered, north half partly open.	Aeromap orthorectified vertical aerial photographs	10,770
October 29, 2004	Interior cauldron-wall retreat exposes horizon of 1992 tephra.	Aeromap orthorectified vertical aerial photographs	–
October 30, 2004	Size of cauldron 130 × 130 meters	Aeromap orthorectified vertical aerial photographs	15,850
December 4, 2004	Lake surface partly covered with ice; little exposed rock visible.	Aeromap orthorectified vertical aerial photographs	19,900
January 11, 2005	Lake surface partly covered with ice; little exposed rock visible.	Aeromap orthorectified vertical aerial photographs	22,970
February 28, 2005	Lake surface almost entirely covered with ice debris except for three circles of roiling; steaming warm rock visible along lakeshore.	AVO gas and observation flight	–
March 2, 2005	Ice covered south side of lake, north half ice-free, steaming warm rock exposed along north lakeshore.	AVO observation flight	27,400
March 26, 2005	Steam in cauldron, ice covered south side of lake, north half ice free.	AVO observation flight	–
April 25, 2005	Ice covered south side of lake, north half ice free; large expanse of exposed rock on north and northwest walls of cauldron.	AVO FLIR and observation flight.	40,800
May 2, 2005	At approximately 11:00 a.m. AST, debris flow observed.	AVO Web camera; pilot report on May 3.	–
May 3, 2005	Observation that lake level had dropped from April 25, likely coincident with debris flow on May 2. Fumaroles in crater are stranded above waterline.	AVO observation flight	40,800
May 10, 2005	Detailed observations made of new debris-flow deposits. Steaming fumaroles above new, lower shoreline; thin fragmental ice cover on south side of lake, north half ice-free.	AVO observation flight	40,800
June 21, 2005	Lake level similar to that seen in May; strong roiling observed in ice-free lake.	AVO FLIR and observation flight.	48,950
July 7, 2005	Another section of cauldron wall starts to founder.	AVO observation flight	59,380
August 1, 2005	Cauldron reaches its present size	AVO observation flight	68,900
September 8, 2005	Lake free of ice, no upwelling noted, yellow precipitate visible along lake shore.	Photographs by D. Schwartz	68,900
October 9, 2005	Lake surface partly covered with dirty ice, fumaroles active along lake shore.	Photographs by D. Dewhurst	–
November 3, 2005	Lake free of ice, no upwelling noted, lake partially obscured by steam.	AVO observation flight	69,250

During 2005, the ice cauldron at the summit of Mount Spurr grew substantially in size (figs. 5 and 6). By January 11, 2005, the ice pit had grown in area to about 22,970 m^2 (~5.7 acres), and about 78 m (255 ft) deep (table 8, fig. 5). Radial growth progressed by the slump and collapse of large blocks of snow and ice into the widening ice pit, and consumption of the ice in the relatively warm lake. Despite the onset of winter and sub-zero temperatures at the summit elevation of Mount Spurr, the lake remained partially ice-free. A February 28, 2005, observation flight noted that the lake was almost completely covered with floating ice debris except for three areas of thermal upwelling; steaming warm rock was observed along the north lakeshore. Over the next few months, much of the northern half of the lake remained ice-free and the area of exposed, steaming rocks enlarged along the north and northwest walls. FLIR measurements conducted on April 25, 2005, revealed that more warm ground was present along the lakeshore, but temperatures of the lake and rocks (5°C [41°F], 40° [104°F], respectively) were about the same as that measured on September 24, 2004 (fig. 7).

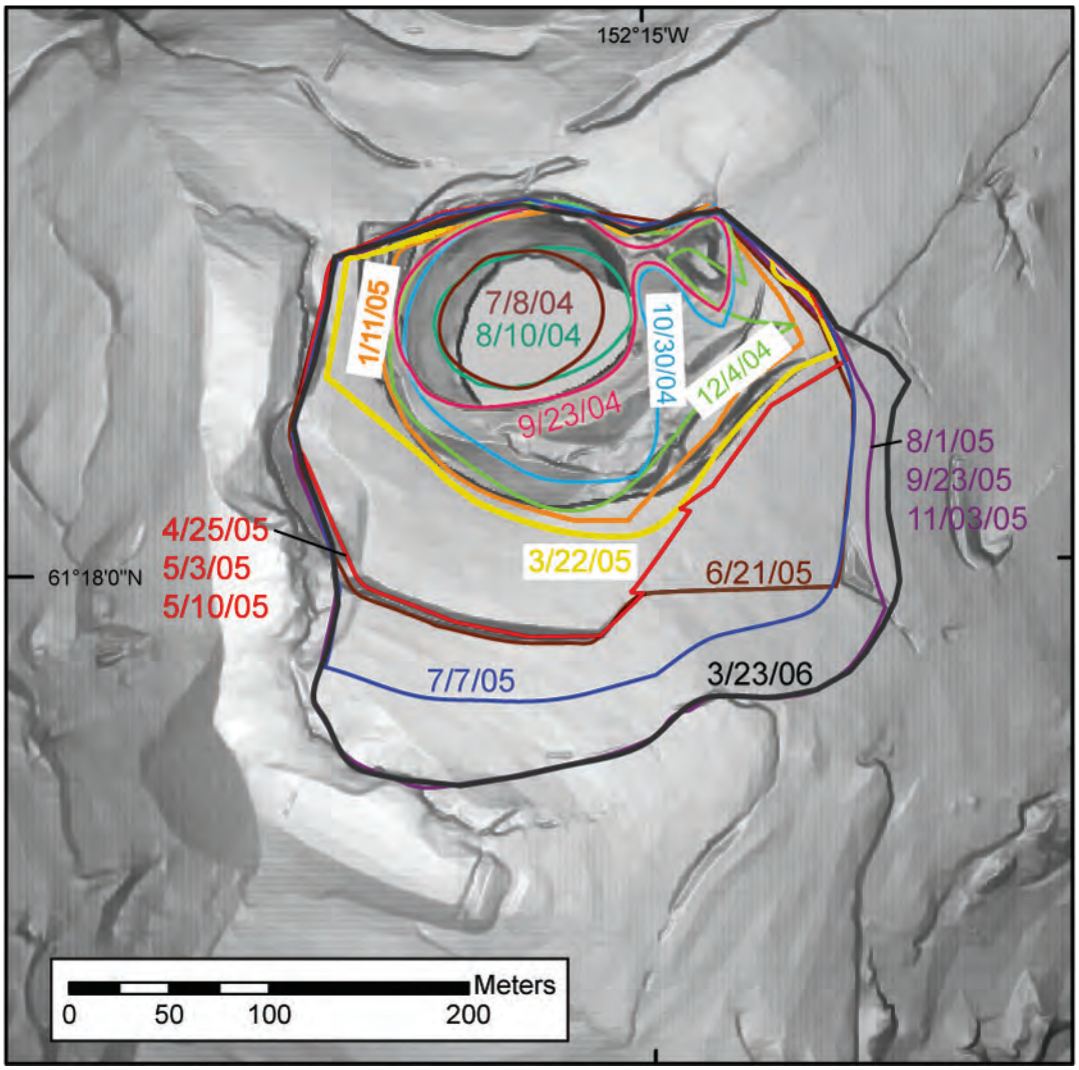


Figure 5. Growth of the summit ice cauldron at Mount Spurr between July 8, 2004, and August 1, 2005. The orange-to-purple lines show the increase during 2005. Mapping was done by Michelle Coombs, AVO/USGS, using GIS to analyze a combination of vertical and oblique imagery. Modified from Coombs and others (2006).

A. Photograph taken by pilot Bruce Hopper on June 20, 2004.

B. Photograph taken by John Power, AVO/USGS, on August 2, 2004.

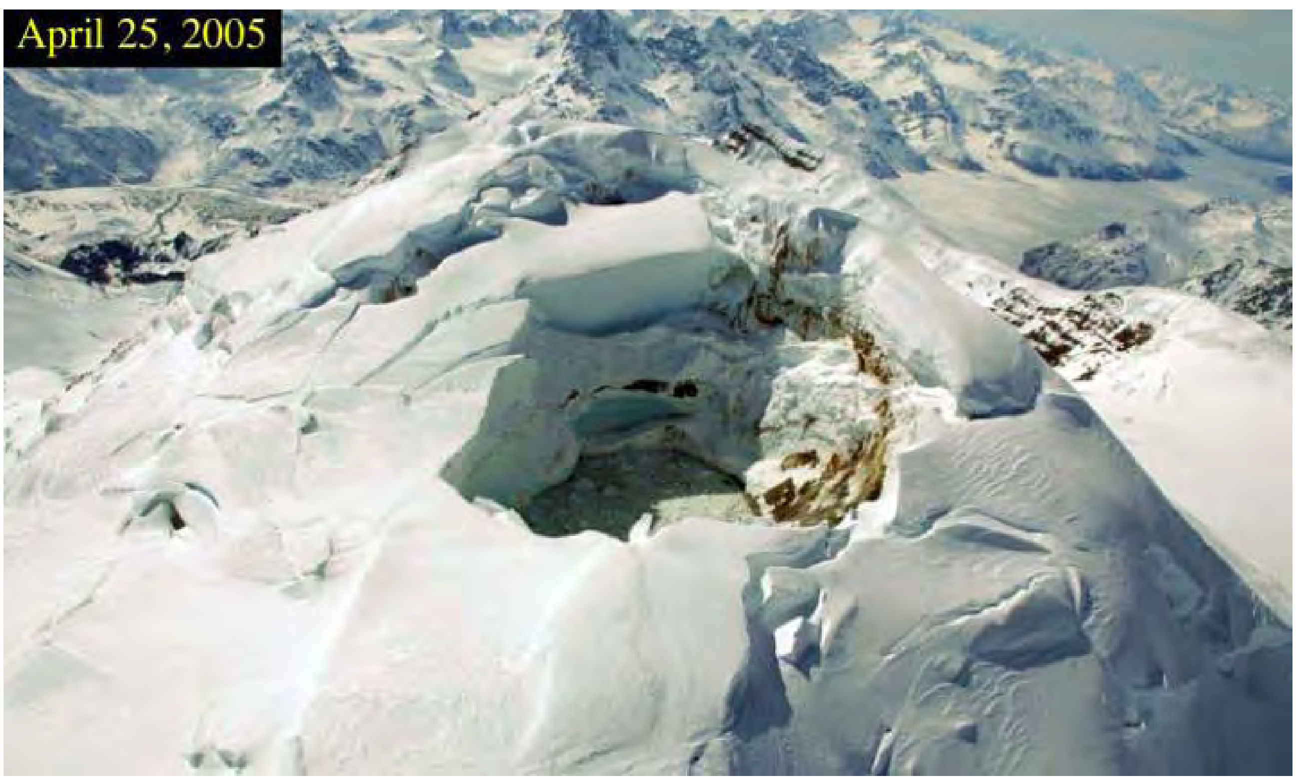
Figure 6. Development of ice cauldron June 20, 2004, to November 3, 2005. All views are from the east.

C. Photograph taken by Michelle Coombs, AVO/USGS, on October 30, 2004.

***D*.** Photograph taken by Michelle Coombs, AVO/USGS, January 11, 2005.

Figure 6. Continued.

E. Photograph taken by Dave Schneider, AVO/USGS, March 26, 2005.



F. Photograph taken by Dave Schneider, AVO/USGS, April 25, 2005.

Figure 6. Continued.

G. Photograph taken by Dave Schneider, AVO/USGS, June 21, 2005.

H. Photograph taken by Christina Neal, AVO/USGS, August 1, 2005.

Figure 6. Continued.

I. Photograph taken by Kristi Wallace, AVO/USGS, September 9, 2005

J. Photograph taken by Michelle Coombs, AVO/USGS, November 3, 2005.

Figure 6. Continued.

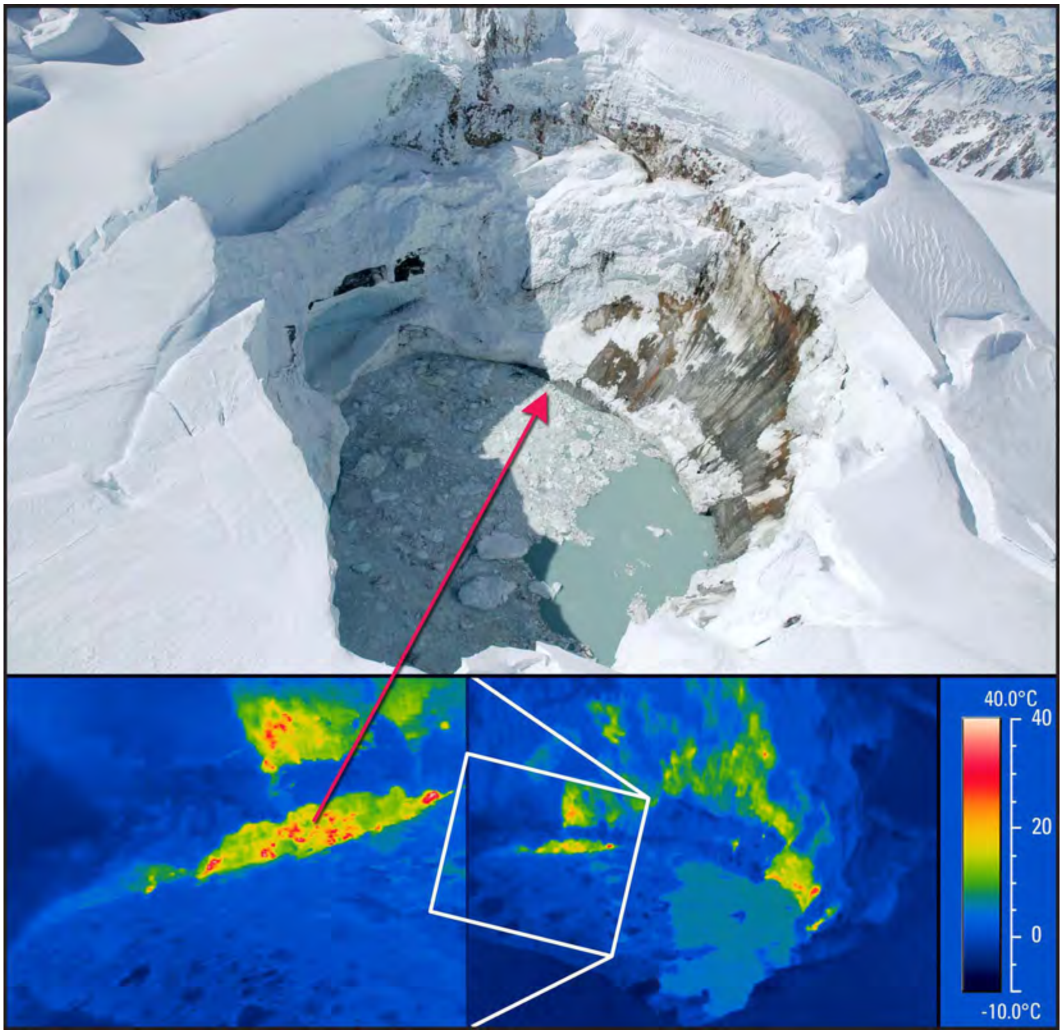


Figure 7. Visual and FLIR views of the Mount Spurr ice cauldron on April 25, 2005. Warmest colors denote the highest temperatures. The exposed rocks along the northern shore of the lake are the warmest (40°C). The lake is just above freezing at 5°C. These temperatures are similar to those of the previous FLIR measurements on September 24, 2004. FLIR measurements, photographs, and analysis were done by Dave Schneider, AVO/USGS.

On May 2, a remote web camera aimed at Mount Spurr captured the advancement of a small debris flow high on the south flank. During an overflight a week later, AVO observers photographed the deposit and outflow source, and discovered that the cauldron lake level had declined about 15 m (50 ft), presumably associated with generation of the debris flow (figs. 8-10). Much more rock was exposed along the north lakeshore and FLIR measurements on June 21, 2005, revealed increasing temperatures for these areas of hot rock (60°C [140°F]; fig. 11); temperature of the lake water remained about 5°C (41°F). The decline in lake level exposed several fumaroles on the north shore, adjacent to the areas of warm rocks. The northern half of the lake remained ice-free. On June 21, strong upwelling was observed in the northern half of the lake and the north shore fumaroles remained vigorous. The lake was observed to be completely free of ice on September 8, and no upwellings were present. Except for some dirty ice seen floating in the lake on October 9, the lake remained ice-free through early November—the last direct observations of the year—and likely through the end of 2005 because the next observations (mid-January 2006) revealed the lake to be completely free of ice and still turquoise in color. Evidence of water flowage from the outlet source for the May 2 debris flow appeared in photographs from late November (fig. 12), a reminder that little is known about the subglacial hydrologic system associated with the summit hydrothermal system.

Figure 8*A*. Location of debris-flow deposits observed on May 2, 2005. Water appears to have exited the snow/ice cover through a small circular conduit, eroded snow and then cascaded vertically, forming a plunge pool. As water and debris spilled out of the pool, the debris flows formed and advanced over the snow surface. A linear depression above the outlet point may mark the conduit path.

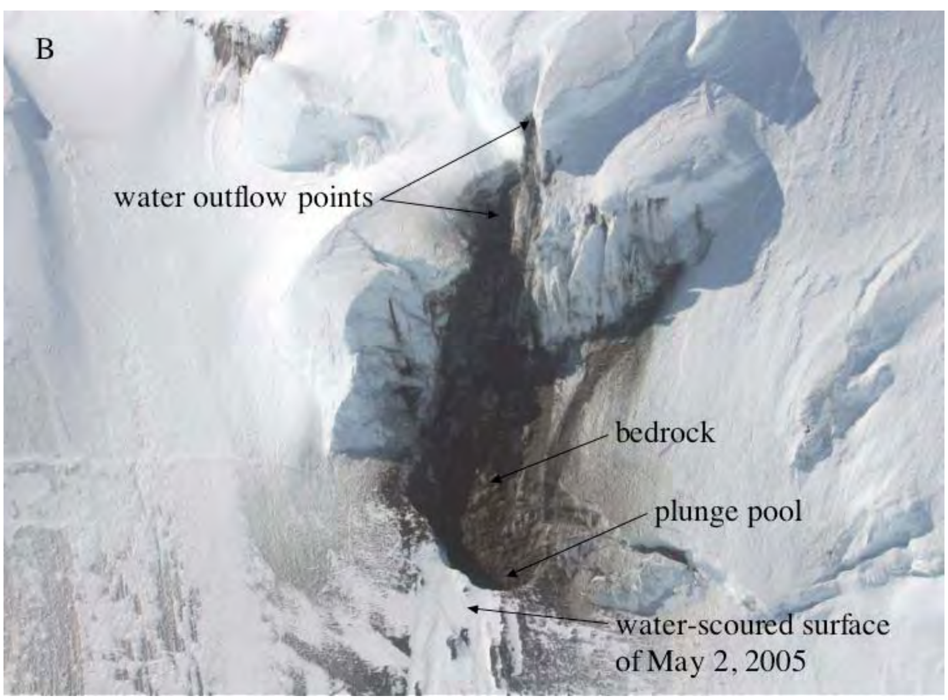


Figure 8*B*. Close-up of the outflow point, plunge pool, scoured bedrock, and head of the debris-flow deposits (covered by fresh snow). Both photographs and interpretive annotations by Chris Waythomas, AVO/USGS, May 10, 2005.

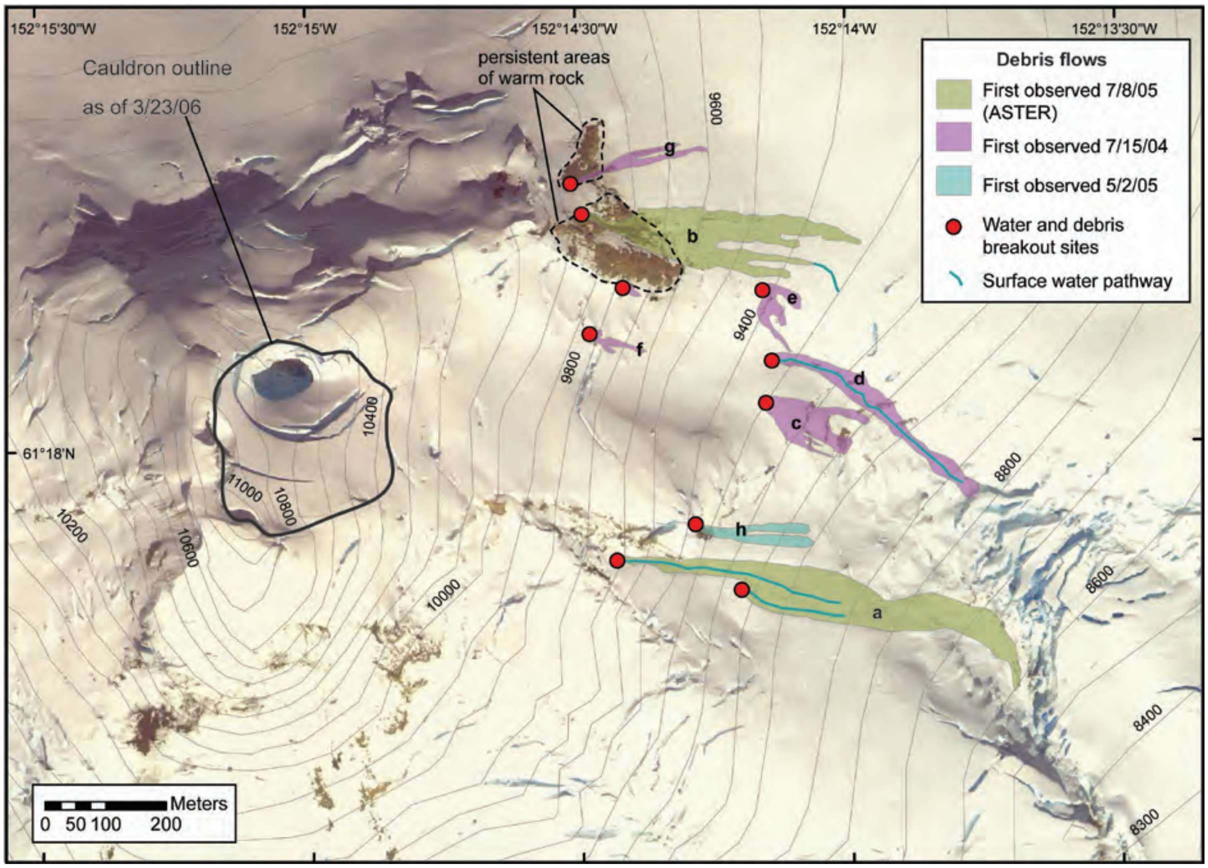
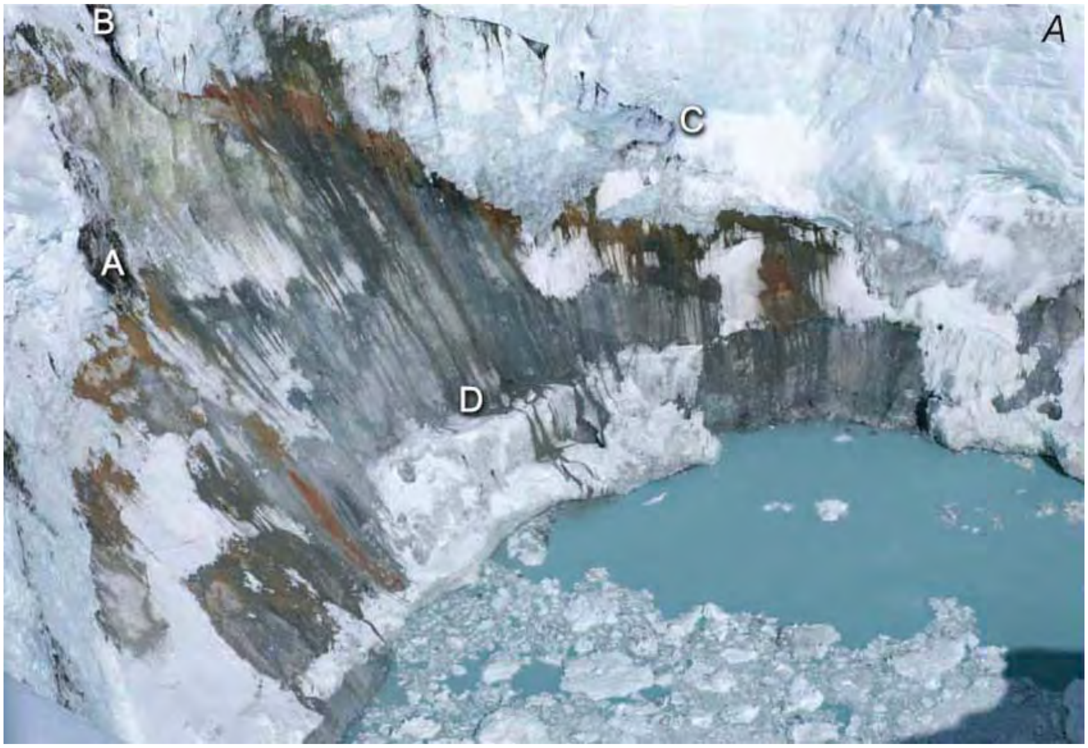
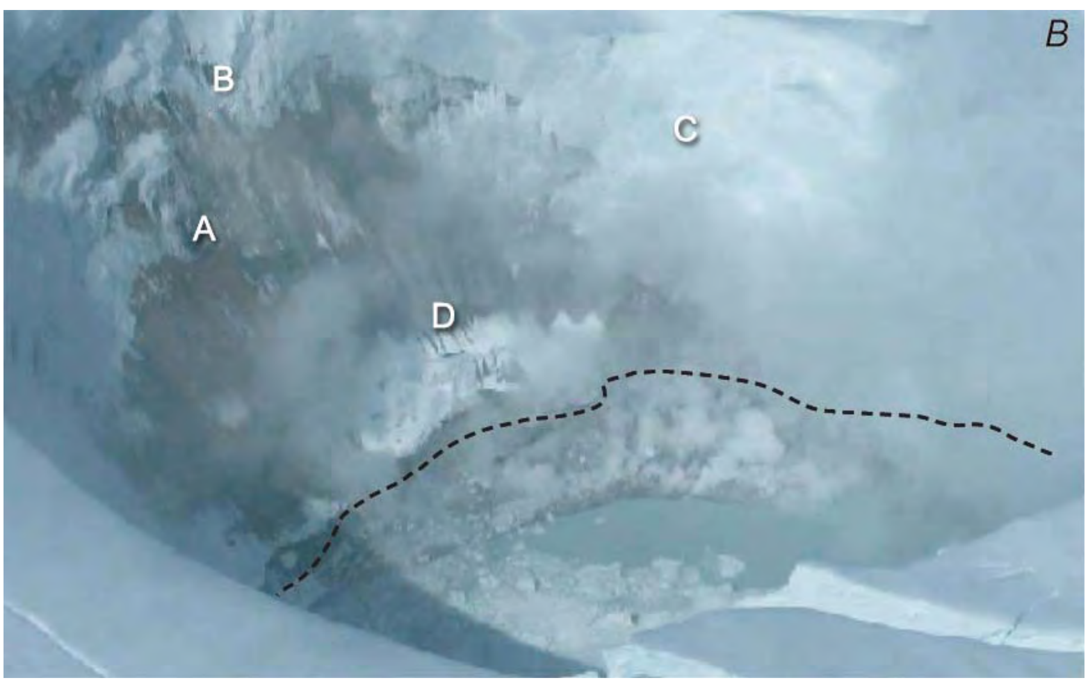


Figure 9. Mount Spurr area and locations of 2004–05 debris flow deposits and other near summit features. The mudflow deposited on May 2, 2005, is labeled "h". Areas within dashed outlines are approximate zones of documented thermal activity. Other letters denote separate mudflows emplaced in 2004.



A. April 25, 2005. Photograph by Dave Schneider, AVO/USGS.



B. May 3, 2005, showing lake-level decline of about 15 m (~50 ft), estimated from 90-m (~300-ft) overall height of predrainage west wall calculated in a September 23, 2004, digital elevation model. Annotations and analysis were done by Michelle Coombs, AVO/USGS.

Figure 10. Spurr summit ice cauldron (*A*) before and (*B*) after lake-level decline that presumably occurred May 2, 2005. May 2, 2005 is the day a web camera captured advance of a small debris flow on the upper south flank of Spurr. A-D, reference features common to both views.

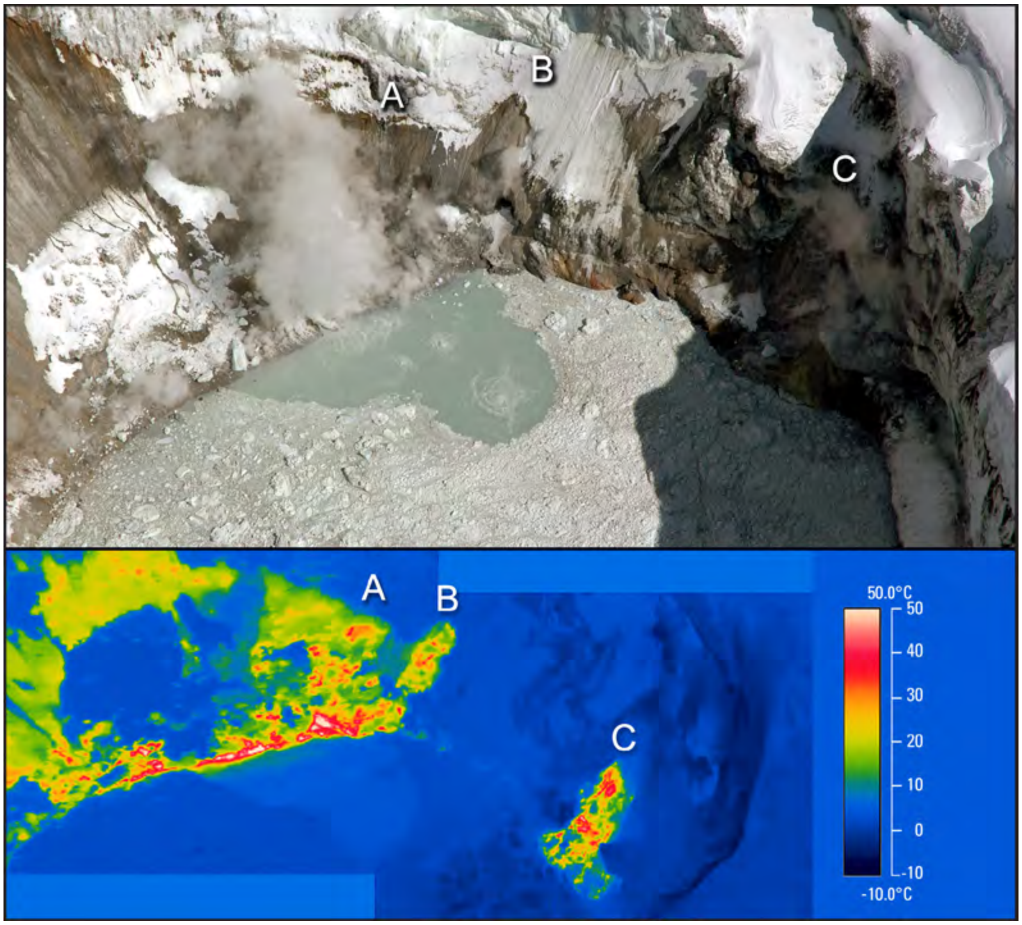


Figure 11. Visual and FLIR views of the Mount Spurr ice cauldron on June 21, 2005. Warmest colors denote the highest temperatures. The exposed rocks along the northern shore of the lake are the warmest (40°C [104°F]). The lake is just above freezing at 5°C (41°F). These temperatures are similar to those of the previous FLIR measurements on September 24, 2004. FLIR measurements, photographs, and analysis were done by Dave Schneider, AVO/USGS.

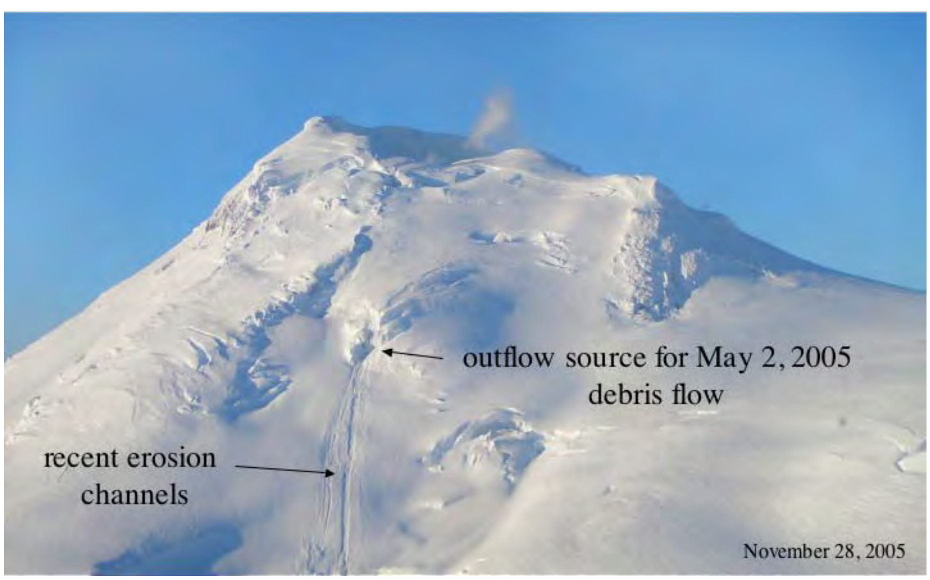


Figure 12. Evidence of water flow out of the same point source—see figure 8—that produced a small debris flow on May 2, 2005. Photograph by Diane Moroney, November 28, 2005.

The ice cauldron continued to increase in size until stabilizing in August 2005 at 68,900 m^2 (17 acres) in area and about 78 m (~255 ft) deep, increasing only slightly to 69,250 m^2 (17.1 acres) as of November 3 (Coombs and others, 2006) (fig. 5). The total volume of snow and ice consumed by the lake as of November 3, 2005, was estimated to be 5.4 million m^3 (7.1 million yd^3) (fig. 13) (Coombs and others, 2006).

Five airborne gas measurements were conducted in 2005 to determine the emission levels of CO_2, SO_2, and H_2S. In 2004, gas measurement results show that CO_2 degassing from the summit of Mount Spurr increased from 600 tonnes per day (t/d) in August to 1,300 t/d in September and finally to 1,400 t/d in October (Neal and others, 2005b). By February 28, 2005, CO_2 emissions had sharply decreased to 327 t/d, however, over the next 3 months, the emission rate increased to 760 t/d before decrease again to 246 t/d in late September. Levels of SO_2 display a somewhat different pattern. Measurements throughout 2004 detected no SO_2. The February 2005 measurement produced an emission rate of 83 t/d, which decreased slightly in March, and then increased to 218 t/d by mid-May. The emission rate decreased sharply to 12–50 t/d by September 20. Only very small amounts of H_2S (≤3 ton/d) were measured on the 2004 flights, a trend that continued throughout 2005 with emissions measured at 0.1–6.7 t/d (all gas data provided by M. Doukas, U.S. Geological Survey, written commun., May 21, 2007).

AVO conducted more than 17 observation overflights of the summit area during 2005, mostly in conjunction with gas and FLIR measurements, equipment maintenance, and field operations. Information about the ongoing situation at Mount Spurr was reported in all 2005 Weekly Updates, and on March 4, a special Information Release was issued specifically to warn climbers and skiers of the hazards associated with approaching the summit area. The ongoing activity at Mount Spurr prompted AVO to conduct several weeks of geologic fieldwork during the summer of 2005 to supplement and revise geologic mapping and age dating studies, and to assess the hazards.

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. An estimated 67 km^3 (~16 mi^3) of ice covered Mount Spurr in 1981, which is about 15 times that of Mount Rainier, Washington (March and others, 1997). Geological studies of Mount Spurr suggest that its last significant eruption was between 5,000 and 6,000 years ago (Waythomas and Nye, 2002). Given its proximity to Anchorage and the potential for severe disruption of the hub of Alaska's economy and population center, Mount Spurr is one of the most extensively monitored volcanoes in Alaska.

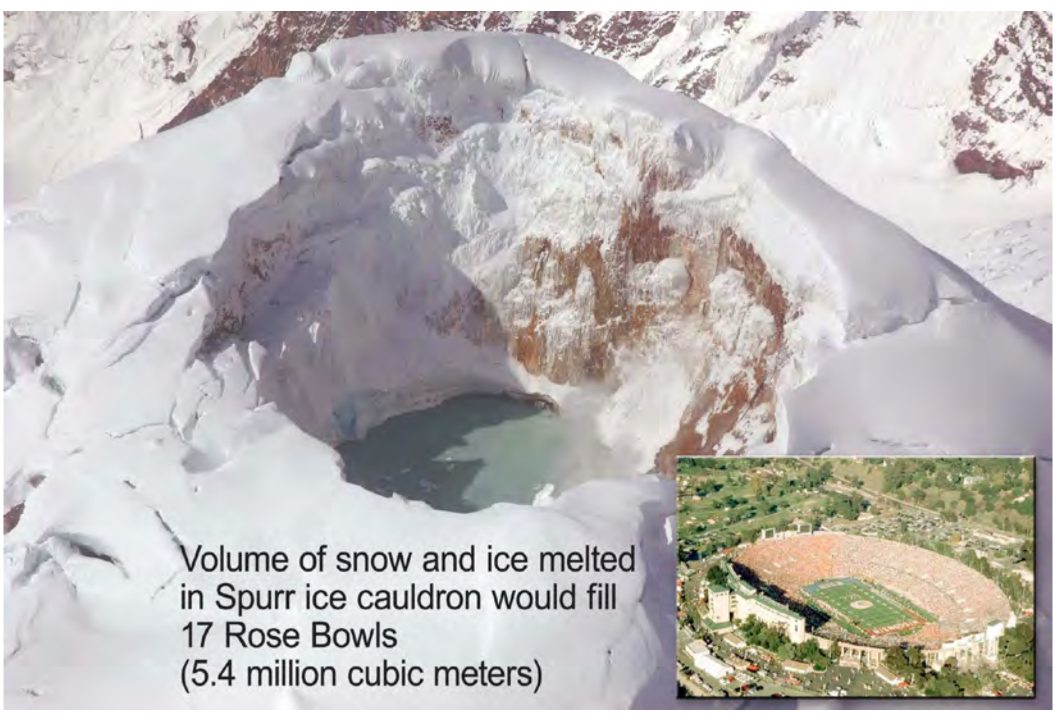


Figure 13. Volume of snow and ice melted in the Mount Spurr ice cauldron. Volume of snow and ice melted by the end of 2005 is about 5.4 million m^3 (7.1 million yd^3) (Coombs and others, 2006), and would fill 17 Rose Bowl stadiums (photographs not to same scale; volume of Rose Bowl is 319,359 m^3). Photograph of Spurr cauldron by Christina Neal, AVO/USGS, August 1, 2005.

Iliamna Volcano

CAVW#1103-02

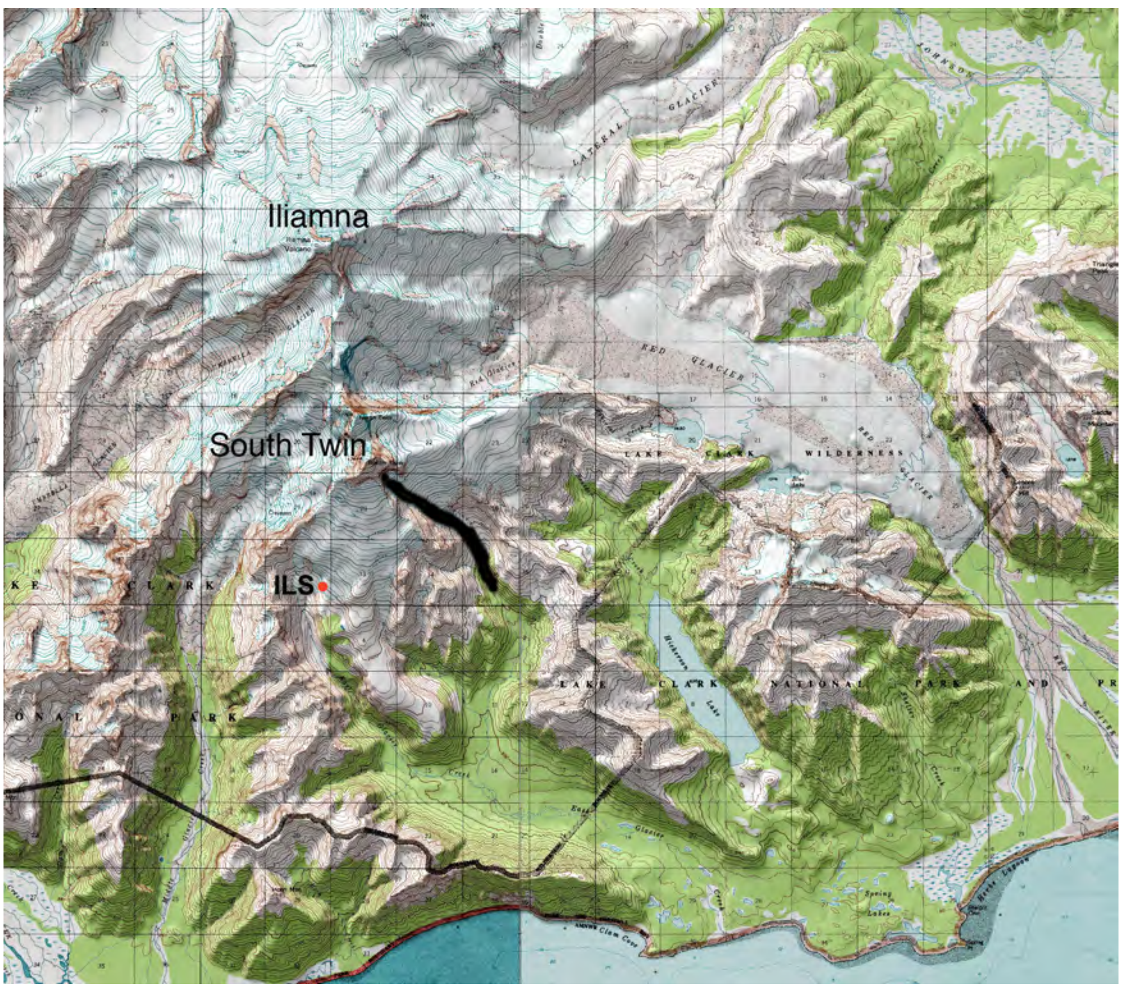
60°02′N 153°04′W
10,017 ft (3,053 m)

Cook Inlet

SVA

Large rock avalanche on SE flank of South Twin produces distinctive seismicity

On May 15, 2005, AVO seismologists noted a swarm of unusual seismic activity at Iliamna. The events were emergent and prolonged (longest lasted 5–8 minutes), and were strongest at seismic station ILS, located on the south flank of South Twin (fig. 14). The activity began about 1250 UTC and tapered off at 1718 UTC. Analysis revealed that the signals most likely were caused by a surficial process, such as a snow avalanche—a common occurrence on Iliamna—but this particular event lacked the usual precursory seismicity preceding other Iliamna snow and ice avalanches (J. Caplan-Auerbach and others, 2004; J. Caplan-Auerbach, written commun., 2005; Caplan-Auerbach and Huggel, 2007).



Base map provided by Chris Waythomas, AVO/USGS.

Figure 14. Area around Iliamna Volcano showing the location of South Twin, the May 15, 2005, rockslide, and seismic station ILS.

Corroborating evidence arrived on the morning of May 17 when Lee Fink of Lake Clark National Park called AVO to offer his observations from an overflight of the area the previous day. Fink reported seeing a large, fresh rock slide (*not* a snow or ice avalanche) southeast of Iliamna that began at about the 6,500- ft level on the southeast flank of South Twin and ran down to about the 1,200-ft elevation (fig. 15). The lengthy ridge extending south of Iliamna that includes South and North Twins and a large unnamed massif has steep, exposed sections of bedrock that frequently generate rock falls, and occasionally large rockslides, such as occurred on May 15 at South Twin.

Iliamna is a dissected ice- and snow-covered stratocone that lies 225 km (140 mi) southwest of Anchorage in the Aleutian Range. No historical eruptive activity has been confirmed; however, a prominent fumarole field near the summit produces a nearly constant steam plume, which often is mistaken for eruptive activity. The fumaroles high on the south and east-northeast flanks occur where large scars reveal that most of the upper edifice consists of highly altered, unstable rock. The eastern scar has been the source of frequent nonvolcanic gravitational collapses that produce mixed avalanches of ice, snow, rock, and mud that typically extend several kilometers down the flank; some are large enough to be visible from the Kenai Peninsula (table 7). Although Iliamna has had no significant eruptive activity within the past 200 years, two strong, shallow, seismic swarms in 1996 indicate that the volcano remains restless. AVO maintains a six-station seismic network on the volcano.

Figure 15*A*. View of Iliamna Volcano from the east. North and South Twins are the prominent peaks south of the summit. Arrow marks location of the May 15, 2005, rock avalanche. Photograph by Christina Neal, AVO/USGS, July 12, 2006.

Figure 15*B*. Rock avalanche on the southeast flank of South Twin.Rock avalanche begins at about the 6,500 ft level and running down to 1,200 ft level. Photograph by Page Spencer, Lake Clark National Park, May 16, 2005.

Augustine Volcano

CAVW #1103-01

56°23′N 153°26′W
1,260 m (4,134 ft)

Cook Inlet

INCREASE IN SEISMICITY, DEFORMATION, GAS EMISSION, AND PHREATIC EXPLOSIONS

Beginning of December 2005–March 2006 eruption

Augustine is the most frequently active volcano in the Cook Inlet area and prior to the recent activity, last erupted in March–April 1986. Minor steaming from fumaroles on and near the summit has been ubiquitous. After nearly 20 years of quiescence, beginning in May 2005, microearthquake activity consisting of one to two events per day was detected, and would increase dramatically to more than 70 per day by mid-December (Power and others, 2006) (fig. 16). Telemetered Global Positioning System (GPS) data—operated through EarthScope/Plate Boundary Observatory—revealed distinctive deformation began in early summer 2005 and accelerated in November 2005, heralding the likely propagation of a small dike to shallow levels beneath the volcano by mid-December (Cervelli and others, 2006). This precursory activity ultimately led to the 2006 eruption of Augustine (Power and others, 2006).

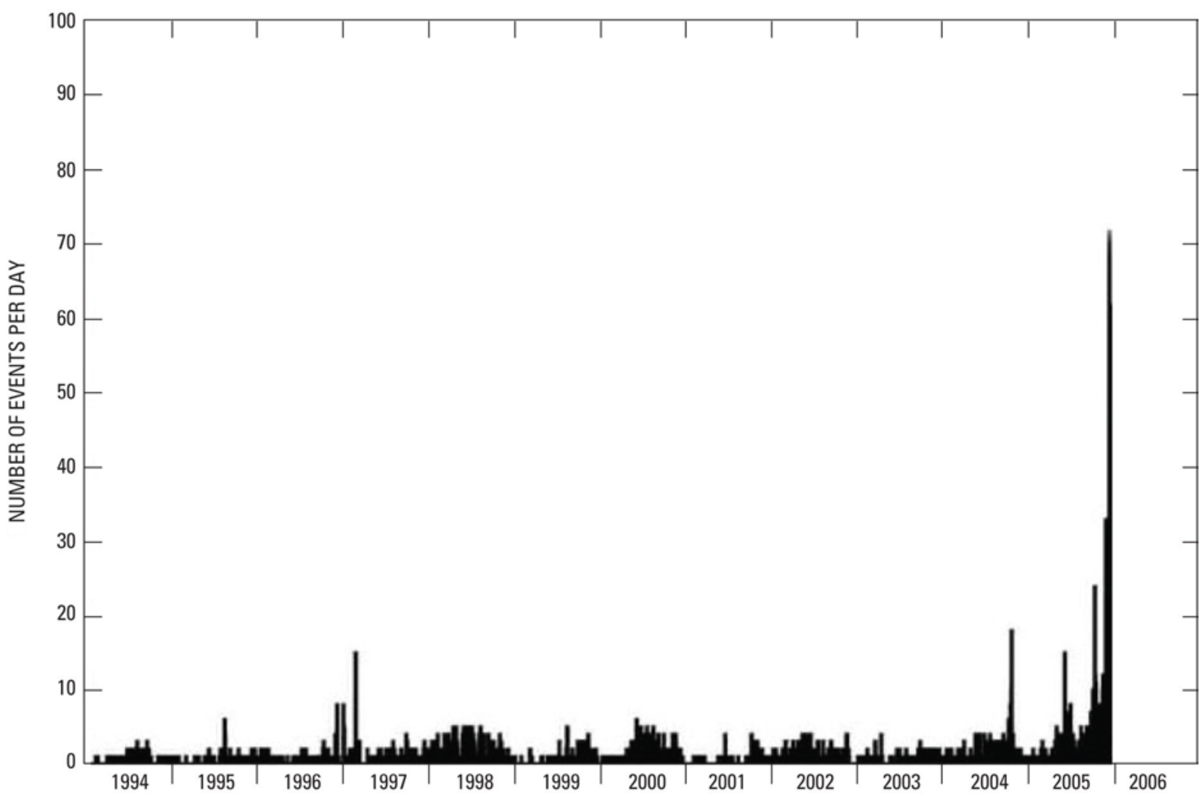


Figure 16. Number of earthquakes located per day beneath Augustine Volcano from the beginning of 1994, through December 31, 2005. The 2005 increase began in early May at two events per day, and by mid-December was more than 70 events per day (J. Power, USGS/AVO, oral commun., 2006).

The seismic signature of small phreatic explosions began in early December with the largest events occurring on December 10, 12, and 15 (Power and others, 2006). Villagers in Nanwalik, located 80 km (50 mi) east of the volcano, reported unusual steaming and strong sulfur odors (H2S) on December 10, and a 145-kilometer-long (90 mi) steam and gas plume was visible in a satellite image on December 12 (fig. 17). AVO overflights on December 12 and 20 documented numerous snow-free areas on the summit, anomalous steaming ground, a vigorous new steam vent on the upper southeast flank, and a light dusting of ash on the southern flanks (later determined to be mostly remobilized tephra and bits of old dome from the 1986 eruption (Power and others, 2006) (fig. 18*A* and 18*B*). Another new, vigorous fumarole was observed on December 22, 2005, along the east margin of the 1986 dome (fig. 18*C*), and FLIR images taken that same day show that much of the summit area was being heated (fig. 19).

Figure 17. Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite image taken on December 12, 2005, 2217 UTC, showing a plume (mostly steam with sulfur gas) extending about 145 km (90 mi) towards the southeast. Image courtesy of the Geographic Information Network of Alaska (GINA) http://www.gina.alaska.edu/.

Figure 18*A*. Vigorous steaming from multiple fumaroles on the summit of Augustine and the upper southeast flank dusted the southern flanks with remobilized ash. Photograph by Game McGimsey, AVO/USGS, December 12, 2005.

Figure 18*B*. Southeast flank of Augustine showing summit steaming, vigorous new steam vent below summit, and ash dusting on snow. View is toward the northwest. Photograph by Chris Waythomas, AVO/USGS, December 20, 2005.

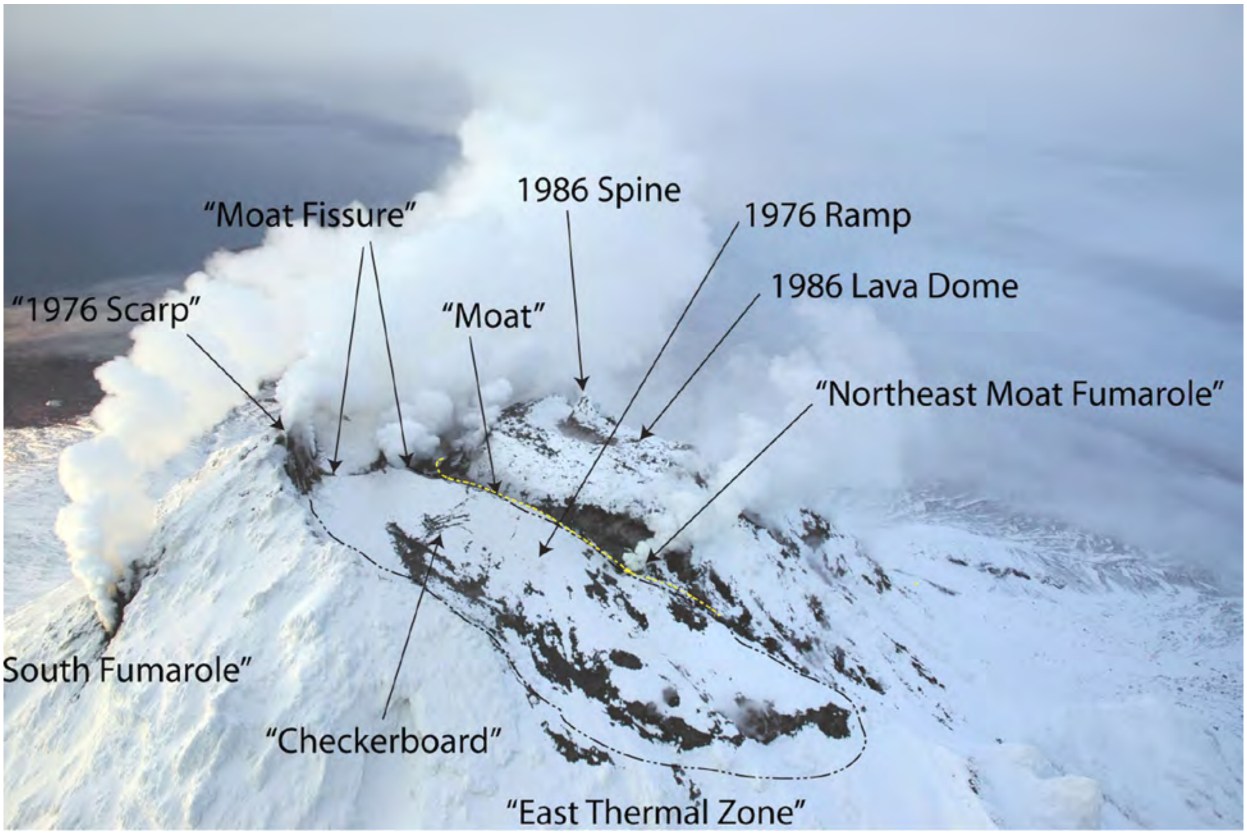


Figure 18*C*. Summit features of Augustine Volcano as viewed from the east. By December 22, 2005, steaming had become more vigorous and an additional fumarole began venting along the east margin of the 1986 dome (Northeast moat fumarole). More bare ground was developing in what became informally known as the checkerboard feature. Photograph by Kristi Wallace, AVO/USGS, December 22, 2005.

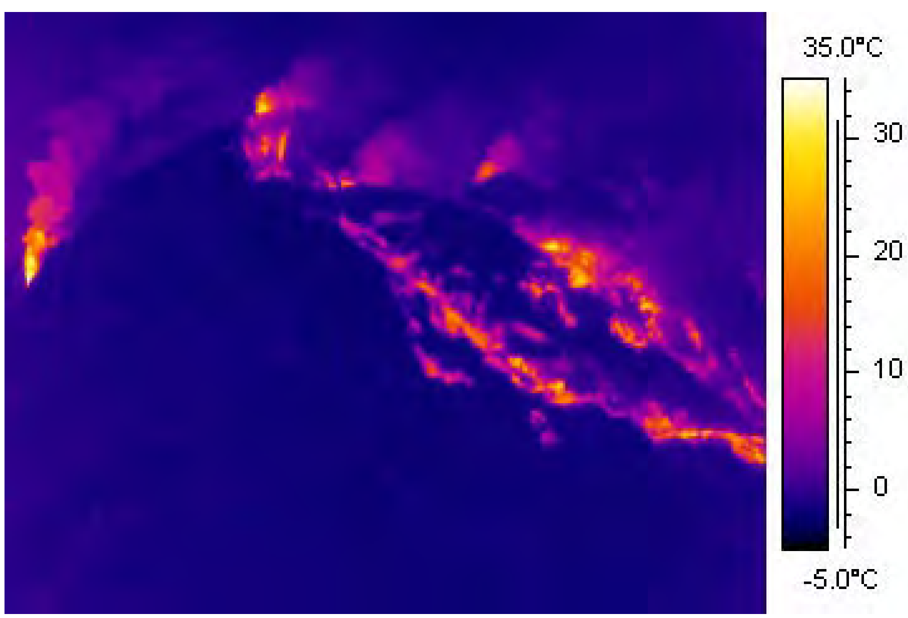


Figure 19. Forward Looking Infrared Radiometer (FLIR) image of the summit of Augustine showing areas of higher heat. Areas of higher heat are shown by warm colors. Image by Dave Schneider, AVO/USGS, December 22, 2005.

Although a measurement of gas emissions on May 10, 2005, indicated no anomalous degassing from the volcano at that time, an emission rate of 600 t/d of SO_2 was measured on December 20, increasing to 6,700 t/d by January 4, 2006 (McGee and others, 2006). The main explosive phase of this Augustine eruption began in earnest on January 11, 2006.

The increase in earthquake and deformation activity prompted AVO to raise the Level of Concern Color Code for Augustine from **GREEN** to **YELLOW** on Tuesday, November 29, 2005, formally notifying the public and other agencies of the unrest (fig. 20). The volcano stayed at **YELLOW** throughout the remainder of 2005 as activity

ALASKA VOLCANO OBSERVATORY
INFORMATION RELEASE
Tuesday, November 29, 2005 12:15 PM AKST (2115 UTC)

AUGUSTINE VOLCANO (CAVW#1103-01-)
59.3633°N 153.4333°W, Summit Elevation 4134 ft (1260 m)
Current Level of Concern Color Code: **YELLOW**
Previous Level of Concern Color Code: **GREEN**

AVO has detected important changes in earthquake activity and ground deformation at Augustine Volcano in southern Cook Inlet. These data are consistent with renewed volcanic unrest. AVO is therefore raising the level-of-concern color code from green to **YELLOW** and will continue to monitor activity closely. There is no indication that an eruption is imminent or certain.

Beginning in May 2005, there has been a slow increase in the number of earthquakes located under Augustine Volcano. The earthquakes are generally small (less than magnitude 1.0) and concentrate roughly 1 km below the volcano's summit. These earthquakes have slowly increased from 4-8 earthquakes/day to 20-35 earthquakes/day. Additionally, data from a 6-station Global Positioning System (GPS) network on Augustine Volcano indicate that a slow, steady inflation of the volcano started in mid-summer 2005 and continues at present. The GPS benchmark located nearest the summit has moved a total of 2.5 cm (1 inch). This motion is consistent with a source of inflation or pressure change centered under the volcano. This is the first such deformation detected at Augustine Volcano since measurements began just prior to the 1986 eruption.

No reports of increased steaming have been received by AVO, nor have satellite data shown increased thermal activity.

Historic eruptions of Augustine typically begin with explosive bursts that may send plumes of ash to 30,000-40,000 feet above sea level. The primary hazards to communities, aviation, and mariners in Cook Inlet and parts of south-central Alaska from an Augustine eruption are ash fall and drifting ash clouds. In 1986, 6 mm (0.25 inch) of ash fell in Homer, 120 km (75 mi) east of Augustine and light ashfall was recorded in Anchorage, 290 km (180 mi) away. Hot, ground-hugging flows of volcanic rock debris called pyroclastic flows may form during an eruption and could be hazardous to people, aircraft, or boats on or in the immediate vicinity of the island.

Island volcanoes can generate tsunamis by collapse into the sea. There is no evidence that conditions are developing that would lead to a major volcanic landslide or similar event at Augustine that, upon entering Cook Inlet, could generate a tsunami. No tsunami waves were generated during any of the last five eruptions of Augustine Volcano.

The full hazard assessment for Augustine Volcano can be obtained at
http://www.avo.alaska.edu/pdfs/augustine_ofr.pdf

Augustine Volcano is a 1260 m high (4134 ft) conical-shaped stratovolcano located on Augustine Island in southern Cook Inlet, about 290 km (180 mi) southwest of Anchorage, Alaska. Augustine is the most historically active volcano in the Cook Inlet region. Historical eruptions occurred in 1812, 1883, 1908, 1935, 1963-64, 1976, and 1986. These eruptions were primarily explosive events that produced volcanic ash clouds and pyroclasic flows. During the 1883 eruption, a volcanic rock avalanche occurred on the north flank of the volcano; it flowed into Cook Inlet and initiated a tsunami observed at Nanwalek, about 90 km to the east.

ABBREVIATED COLOR CODE KEY (contact AVO for complete description):
GREEN volcano is dormant; normal seismicity and fumarolic activity occurring
YELLOW volcano is restless; eruption may occur
ORANGE volcano is in eruption or eruption may occur at any time
RED significant eruption is occurring or explosive eruption expected at any time

Figure 20. AVO Information Release on Tuesday, November 29, 2005, wherein the Level of Concern Color Code for Augustine was raised from GREEN to YELLOW. This was the first formal warning of unrest.

escalated (table 6). To enhance our capabilities to track the unrest in December 2005 and early 2006, AVO deployed additional components to the array of monitoring equipment already on the island, including six new broadband seismometers, five temporary GPS receivers, an atmospheric pressure transducer, two web cameras, a time-lapse camera, and ash-collection buckets (Power and others, 2006) (fig. 21).

Augustine volcano forms an 8 × 11 km (5 × 7 mi) island at the mouth of Cook Inlet (fig. 22). The stratocone comprises volcaniclastic debris skirting a large, steep-sided summit dome complex composed of the large dome emplaced during the 1986 eruption, as well as a cluster of dome remnants from previous historical eruptions. The lower flanks primarily are overlapping deposits of debris avalanches from numerous catastrophic collapses of summit domes during the past 2,000 years, the most recent having occurred in 1883 (Beget, 1986; Beget and Kienle, 1992). The nearest city is Homer, located about 100 km (62 mi) northeast across Cook Inlet. At least seven historical eruptions are attributed to Augustine (Miller and others, 1998).

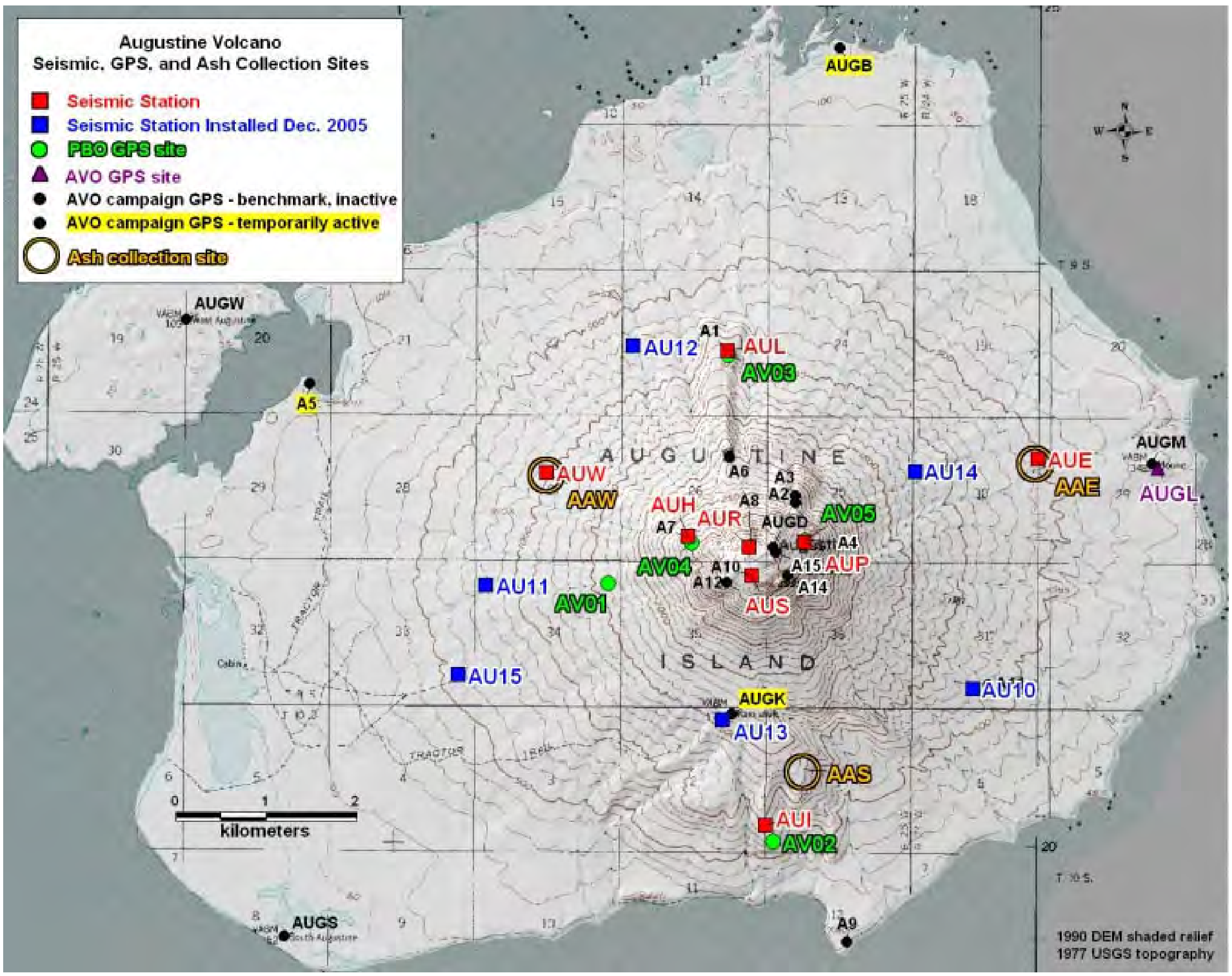


Figure 21*A*. Augustine seismic, GPS, and ash collection sites as of December 28, 2005. Compiled by Janet Schaefer, AVO/ADGGS.

Figure 21*B*. Tom Fournier (AVO/UAFGI) installing the Kamishak campaign Global Positioning System (GPS) station. GPS station (AUGK) is shown in figure 15*A*. The south flank of Augustine and new southeast fumarole loom above. Photograph by Max Kaufman, UAFGI, December 22, 2005.

Figure 21*C*. Kristi Wallace (AVO/USGS) deploying an ash collection bucket. Photograph by Dave Schneider, AVO/USGS, December 22, 2005.

Figure 22. An apron of pyroclastic debris extends from the summit of Augustine Volcano to sea level. The western shore of Cook Inlet can be seen in the distance. View is to the west-southwest. Panorama photograph by Game McGimsey, AVO/USGS, March 10, 2006.

Katmai Group (Mounts Martin and Magelik, Trident)		
Mount Martin	Mount Mageik	Trident
CAVW#1102-14 58°10′N 155°21′W 1,860 m (6,102 ft)	CAVW#1102-15 58°11′N 155°14′W 2,165 m (7,100’)	CAVW#1102-16 58°14′N 155°07′W 1,097 m (3,600’)
Alaska Peninsula [Note: For purposes of this report, the Katmai Group includes Kukak, Snowy, Katmai, Trident, Novarupta, Mageik, and Martin Volcanoes (all closely situated within Katmai National Park and Preserve on the Alaska Peninsula)] SVA Steam plumes; possible new crater; and clouds of redistributed ash		

On February 26, AVO received from the Center Weather Service Unit (CWSU) several pilot reports of a steam cloud rising to 12,000 ft (3,660 m) from Katmai. An inspection of the webicorders, spectrograms, and satellite logs revealed nothing unusual. Because Katmai Volcano does not have active fumaroles, the reported activity was attributed to nearby Mounts Mageik or Martin, both of which have active fumaroles that frequently produce noticeable steam plumes. Nonvolcanic meteorological phenomena that commonly are mistaken for volcanic activity also are common in this region.

AVO Coordinating Scientist John Eichelberger was leading an annual student fieldtrip into the Valley of Ten Thousand Smokes (VTTS) in June 2005 when, from the rim of Trident Volcano, he observed a new crater about 50 m (165 ft) in diameter. Eichelberger has traversed the VTTS for many years and verified that the crater was not present during his 2003 trip; clouds prevented viewing the area of the crater in 2004. Although no anomalous seismicity was noted in the Katmai area in 2003 and 2004, a period of tremor-like signal occurred in the Katmai area on April 27 as noted in the AVO Seismic Logs. No correlation has been determined.

Beginning on November 3, strong winds in the Katmai area entrained loose 1912 volcanic ash, formed a substantial cloud, and carried it eastward over Kodiak Island. AVO first detected the ash in a MODIS satellite image that day (fig. 23). National Weather Service estimated the top of the plume at 5,000 ft (1,525 m). AVO reported the phenomenon in the November 4 Weekly Update, and the National Weather Service (NWS) Alaska Aviation Weather Unit (AAWU) issued two SIGMETS based on AVO’s detection of the ash cloud. The activity continued for 1 week with the last occurrence reported on Friday, November 10. Clouds of remobilized 1912 ash are common during favorable wind conditions. A similar cloud was observed and reported in 2003 (McGimsey and others, 2005b, fig. 10). The phenomenon is considered an aviation hazard (Hadley and others, 2004).

Martin and Mageik are adjacent, mostly ice-covered stratovolcanoes within Katmai National Park and Preserve on the Alaska Peninsula (figs. 1 and 24*A* and 24*B*). Other than fumarolic activity from summit craters, there are no credible reports of historical eruptive activity at either volcano (Fierstein and Hildreth, 2000). Steam from the 500-m-wide (1,640 ft) summit crater of Martin is vigorous and nearly continuous, with plumes occasionally rising 600 m (2,000 ft) or more above the vent and extending downwind as much as 20 km (12 mi). Steam plumes rising from the summit crater of Mageik also are common. This activity at both volcanoes results in frequent telephone calls to AVO, and SVAs regarding these two Katmai Group volcanoes appear regularly in the AVO annual summary reports (table 7). Trident is a cluster of four contiguous stratocones and numerous domes adjacent to Katmai Pass (between Katmai Volcano and Mount Mageik) and is the site of the Katmai Group’s most recent volcanic activity, wherein a new fragmental cone and lava-flow apron was built between 1953 and 1974 (Hildreth and others, 2001).

The VTTS formed June 6–8, 1912, during a 60-hour cataclysmic eruption from the Novarupta vent. The caldera-producing eruption was the largest on earth in the 20th century, resulting in 11 km^3 (2.6 mi^3) ignimbrite that filled a preexisting glacial valley to a maximum depth of 200 m (600 ft), and 17 km^3 (4 mi^3) of fall deposits, collectively representing 13 km^3 (3 mi^3) of magma volume (Hildreth and others, 2003).

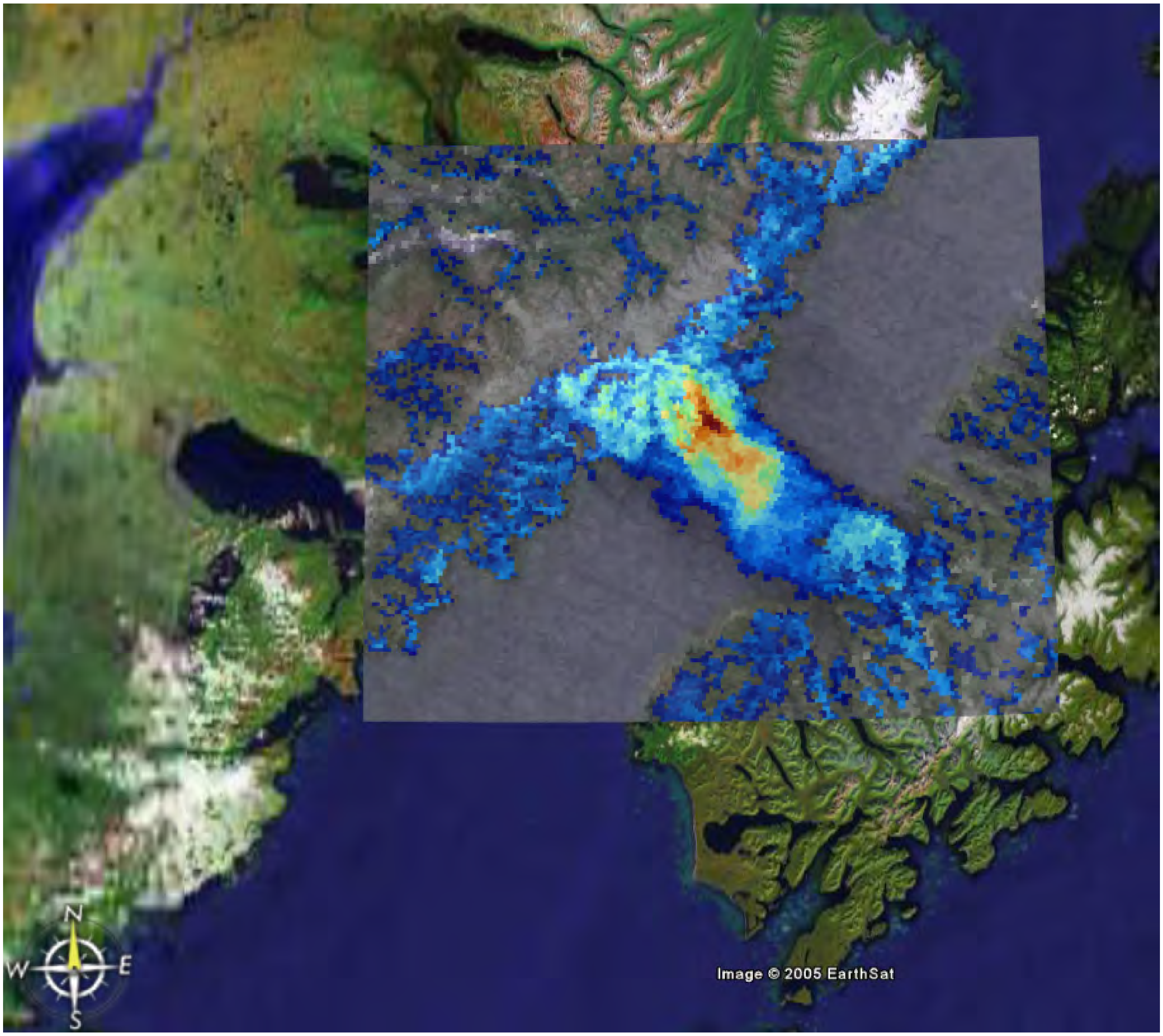


Figure 23. Google Earth image overlain with MODIS color 4 minus 5-band satellite image showing the cloud of remobilized 1912 ash that developed during high winds along the middle of the Valley of Ten Thousand Smokes in Katmai on November 3, 2005. The cloud was carried over Kodiak Island and out over the Gulf of Alaska. Image provided by John Bailey, AVO/UAFGI.

Figure 24*A*. Locations of Katmai Group volcanoes. Red contours indicate original thickness of the Novarupta 1912 ashfall. From Fierstein and Hildreth (2003).

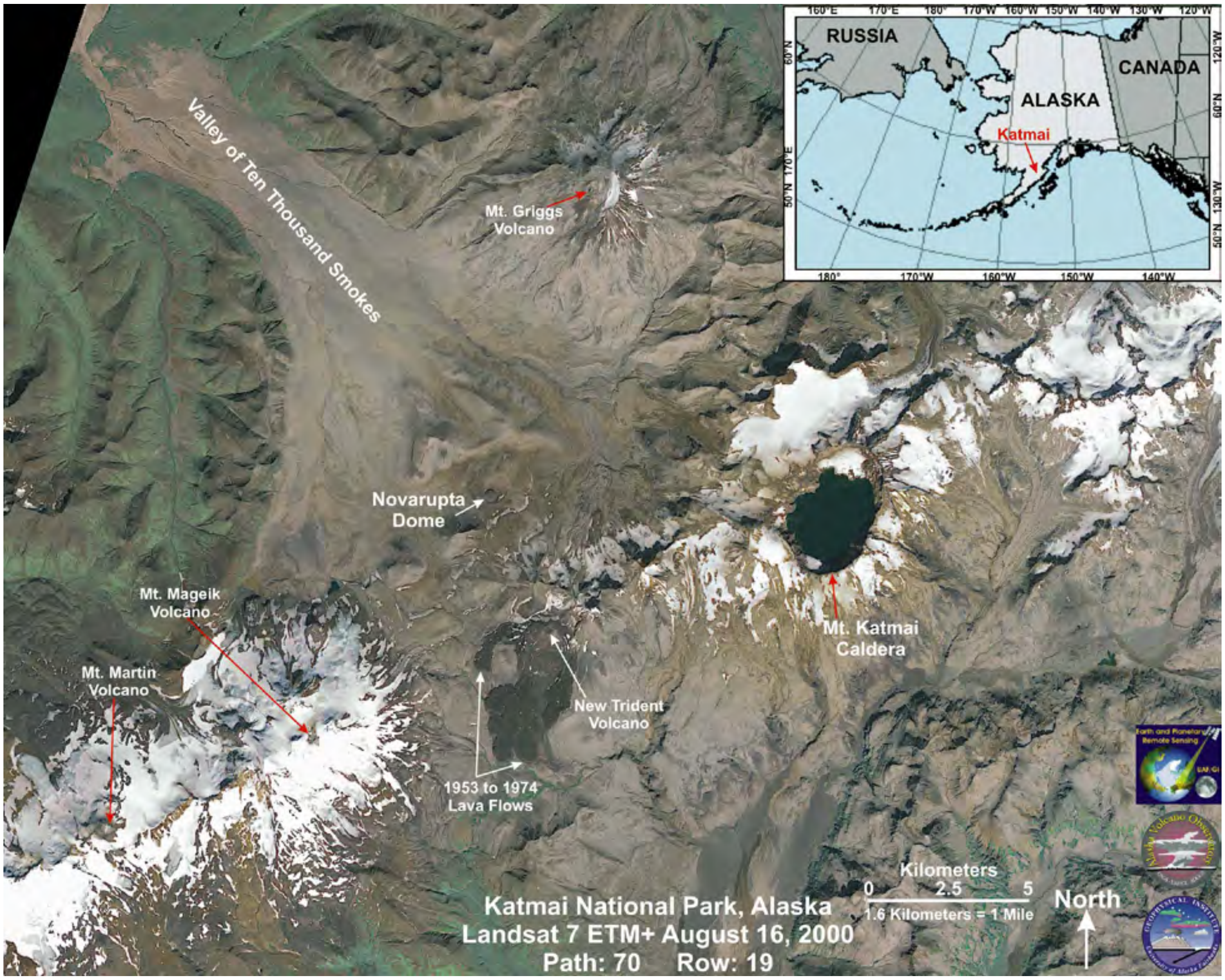


Figure 24*B*. Landsat true color composite satellite image of Katmai National Park region of Alaska taken on August 16, 2000 showing the Valley of Ten Thousand Smokes and volcanoes of the Katmai Group. Image courtesy of Steve Smith, AVO/UAFGI.

Chiginagak Volcano

CAVW# 1102-11

57°08′N 157°00′W
2,135 m (7,005 ft)

Alaska Peninsula

FORMATION OF CRATER LAKE AND OUTBURST FLOOD OF ACIDIC WATER

Summit snowcap melts forming acid lake; catastrophic acid water and aerosol drainage; damage to fish and vegetation

Between November 2004 and early May 2005, a flux of heat to the summit area caused melting of more than 1.3×10^{7} m^{3} (4.6×10^{8} ft^{3}) of ice and snow filling the summit crater of Chiginagak, resulting in a 400-m wide (~1,300 ft) and 105-m deep (~350 ft) cauldron containing an acidified lake (Schaefer and others, 2005; J.R. Schaefer and others, AVO/ADDGS, written commun., 2007) (figs. 25 and 26). In early May 2005, a catastrophic release of sulfurous, clay-rich debris and acidic water from the lake, with an accompanying acidic aerosol component, traveled 27 km (~17 mi) downstream and flowed into Mother Goose Lake, headwaters of the King Salmon River (figs. 27 and 28). Extensive vegetation damage occurred along the flood route and Mother Goose Lake was acidified (pH of 2.9–3.1), killing all aquatic life and preventing the annual salmon run (J.R. Schaefer and others, AVO/ADDGS, written commun., 2007). AVO volcanologists were to begin the second summer of geologic mapping and hazard assessment at the volcano, but instead responded by documenting the flooding and damage, collecting water samples, measuring water temperature, conductivity, and pH, and surveying the extensive vegetation damage with a U.S. Fish and Wildlife Service botanist. A data-logging seismometer was deployed for about 1 month with no significant seismicity recorded; Chiginagak currently does not have a seismic network.

AVO issued an Information Release about the activity on August 23, 2005, shortly after the field crew arrived on site, and an account was related in the Weekly Update (August 26). A summary of preliminary findings is presented by Schaefer and others (2005).

Chiginagak is a symmetric stratovolcano about 8 km (5 mi) in diameter located 175 km (110 mi) south of King Salmon on the Alaska Peninsula. Extensive glacial erosion on the south flank has exposed highly altered interbedded lava flows and breccias, and evidence of an extensive hydrothermal system. The uppermost 1,000 m (3,280 ft) of the cone is covered with perennial snow and ice, including the small ice-filled summit crater. A long-lived fumarole field high on the north flank at about 5,500 ft (~1,675 m) continuously emits steam and sulfur gases. Low on the northwest flank, a cluster of thermal springs produces an estimated 6,100 liters per minute (L/min) of heated water, the warmest measured consistently at 66°C (151°F) (Motyka and others, 1981; 1993). Reports of historical eruptions at Chiginagak are few, and questionable (Miller and others, 1998). The area is remote, and the active fumaroles frequently produce visible steam plumes, which have been mistaken for eruptive activity. Unverified reports of minor activity are attributed to 1852, 1929, and 1971. An event similar to the outburst flooding in 2005 may have occurred in the early 1970s according to third-person accounts from a cabin owner on Mother Goose Lake, who reported flooding from the volcano, discoloration of the lakeshore, vegetation damage, and interruption of the annual salmon run (Jon Kent, local lodge owner, oral commun., 2004).

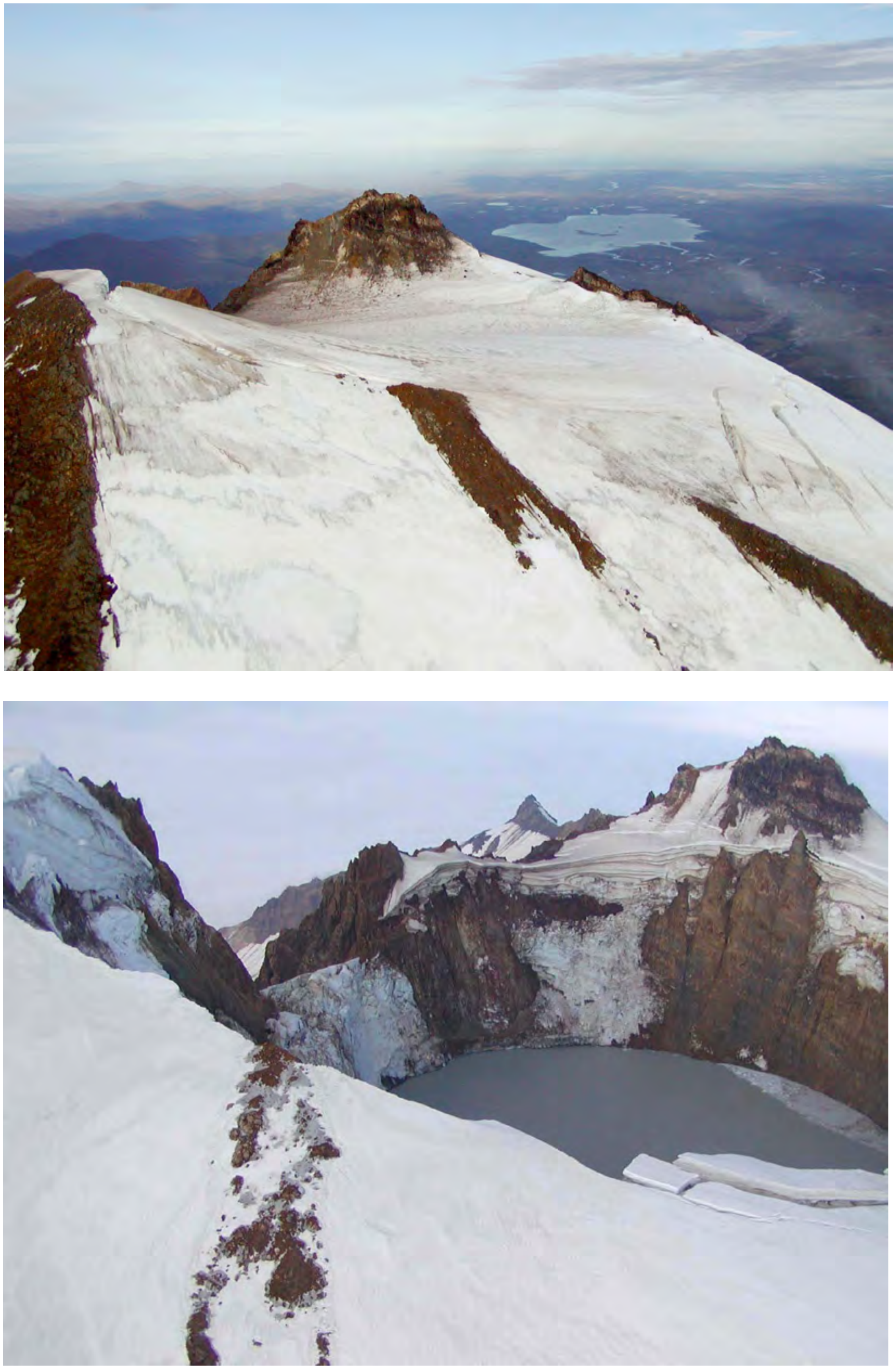


Figure 25. Summit of Chiginagak on August 24, 2004 (top), and August 20, 2005 (bottom), following the melting of substantial snow and ice and formation of the acidic lake-filled cauldron. View from the south-southeast. Both photographs by Janet Schaefer, AVO/ADDGS.

Figure 26. Summit of Chiginagak on August 24, 2004 (top), and August 21, 2006 (bottom), after formation of lake-filled cauldron. Acidic floodwaters exited the lake through a tunnel and surface holes in the outflow glacier. View from the southwest. Top photograph by Janet Schaefer, AVO/ADDGS; bottom photograph by Game McGimsey, AVO/USGS.

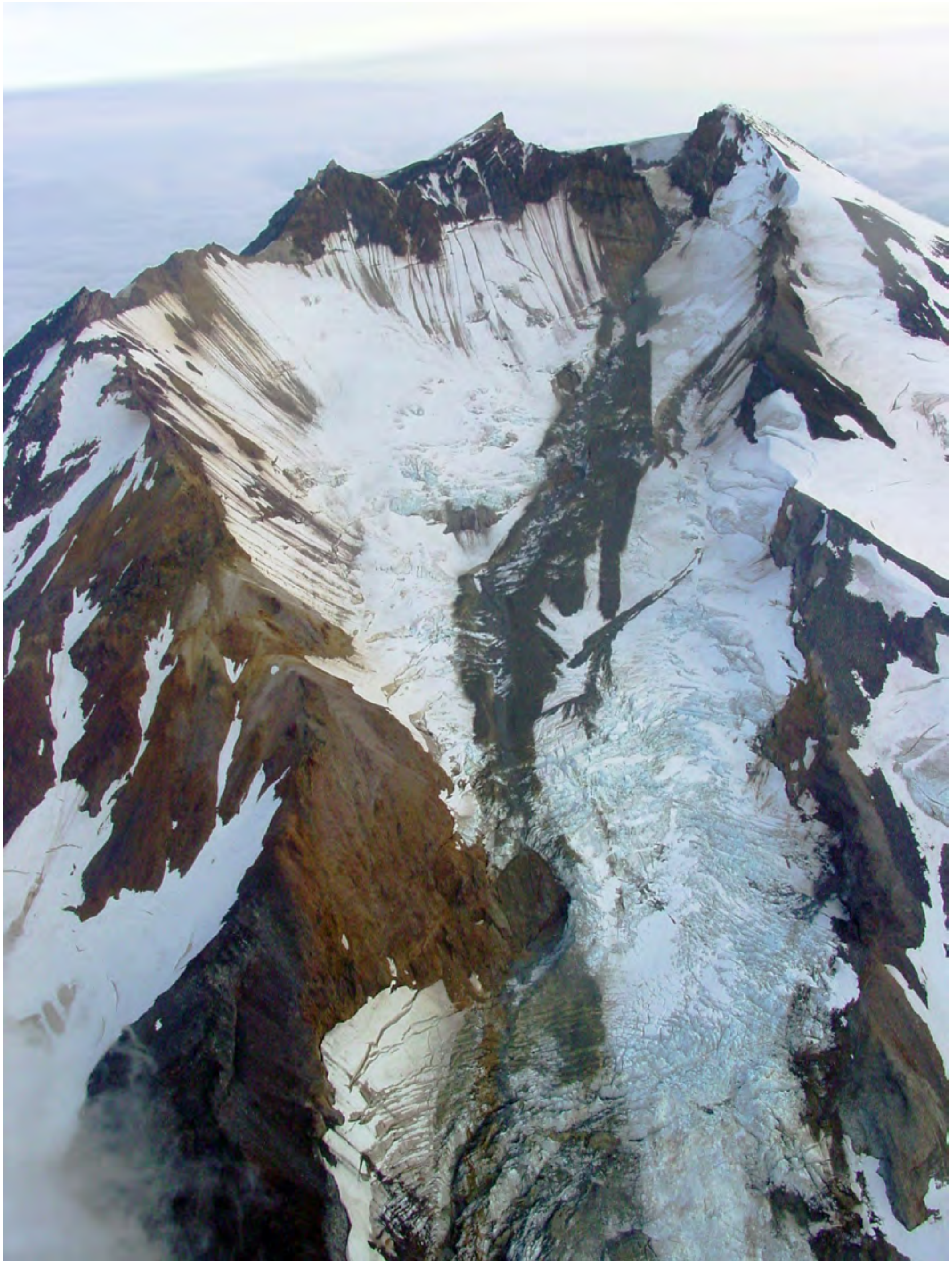


Figure 27. Lahar deposit on southwest flank glacier of Chiginagak Volcano from partial draining of the summit cauldron acidic lake. The event likely occurred in early May 2005. Note that portions of the deposit originate from point sources (crevasses) on the glacier and indicate a subglacial component to the flood. Photograph by Game McGimsey, AVO/USGS, August 20, 2005.

Figure 28. A catastrophic flood of acidic water and aerosols from Chiginagak in early May 2005 damaged and killed vegetation along and adjacent to the 27-km flow path. Photographs by Game McGimsey, AVO/USGS, August 21, 2005.
Top photograph: Middle reach of Indecision Creek, the brown and red colors are areas of damaged or dead vegetation. Mother Goose Lake in distance.
Bottom photograph: Upper Indecision Creek, at the base of Chiginagak, where steep drainage from the southwest flank glacier (right) joins the Indecision drainage. Extensive vegetation damage marked by red and brown coloration.

Aniakchak Volcano

CAVW# 1102-09

56°53′N 158°10′W
1,021 m (3,350 ft)

Alaska Peninsula

SVA

Unusual seismicity; thermal anomaly; intracaldera lake partially ice-free in winter

Beginning in mid-December 2004 and continuing into January 2005, several series of 10–20 low-frequency seismic events showed up on the Aniakchak seismic network. On January 11, 2005, returning from an observation flight over nearby Veniaminof Volcano AVO staff photographed a partially ice-free Surprise Lake within the Aniakchak caldera (fig. 29). A thermal anomaly of unknown source was detected in satellite data on February 1–3, 2005. Subsequent analysis and discussion among AVO scientists regarding these phenomena concluded that nothing unusual was likely occurring, and no further activity was noted in succeeding months.

Figure 29. Aerial view of the partially ice-free west end of Surprise Lake, located within Aniakchak caldera. Thermal springs occur at the base of the cone near the end of the lake, center of photograph. The lake typically is frozen during the core winter months. Photograph by Dave Schneider, AVO/USGS, February 1, 2005.

Aniakchak is a 10-km-wide (~6 mi) caldera located midway down the Alaska Peninsula, 670 km (415 mi) southwest from Anchorage (fig. 30). Formed during a colossal eruption about 3,430 years BP (Miller and Smith, 1987), Aniakchak has since had many eruptions from numerous intracaldera vents (Neal and others, 2001). The only historical eruption occurred in 1931 and was one of the largest explosive eruptions in Alaska in the past 100 years. Long-lived thermal springs are known at the west end of Surprise Lake and several areas of warm ground occur elsewhere in the caldera. A seismic network was installed at Aniakchak in 1997 (table 1).

Figure 30. Aerial view, looking east, of Aniakchak caldera, one of the most spectacular volcanoes on the Alaska Peninsula. Formed during a catastrophic ash-flow producing eruption about 3,400 years ago, the caldera is about 10 km (6 mi) across and averages 500 m (1,640 ft) in depth. Extensive postcaldera eruptive activity has produced a wide variety of volcanic landforms and deposits. The volcano is located in Aniakchak National Monument and Preserve, Alaska. Photograph by M. Williams, National Park Service, 1977.

Mount Veniaminof Volcano

CAVW #1102-07

56°10′N 159°23′W
1,021 m (8,225 ft)

Alaska Peninsula

INTERMITTENT PHREATIC AND STROMBOLIAN ERUPTION

Intermittent, small ash and steam plumes from the intracaldera cone. Ash fall limited mostly to ice-filled summit caldera; Color Code changes eight times

During 2005, Veniaminof resumed a pattern of multiple-month-long periods of unrest with intervening months of quiescence similar to what occurred during 2002, 2003, and 2004 (table 7). After almost 4 quiet months, on January 4, 2005, AVO received a pilot report of small bursts of ash from the active cone rising a few hundred meters and drifting east, producing a narrow spoke-like deposit on snow within the caldera (figs. 31 and 32). This activity seemingly correlated with a period of continuous tremor recorded on the local seismic network that day, and a weak thermal anomaly was detected in an AVHRR satellite image. AVO upgraded The Level of Concern Color Code for Veniaminof from **GREEN** to **YELLOW**. AVO seismologists noticed that weak seismic tremor had begun on January 1 and increased over the subsequent week to levels last observed in May–June 2004. Steam and ash emissions continued for the next several days and residents of Perryville, located 35 km (22 mi) south of Veniaminof, reported incandescence; the caretaker at a local hunting lodge located west-southwest of the volcano reported seeing intermittent bursts of steam and ash. Beginning on January 8, a persistent thermal anomaly began appearing in satellite images. Then, on January 10, following nearly 48 hours of minor but nearly continuous ash emissions—some bursts reaching to 13,000 ft (3,692 m) above sea level—AVO raised the Level of Concern from **YELLOW** to **ORANGE**. The maximum amplitude of the seismicity had by then slightly exceeded that observed during the previous phase of unrest, which ended in September 2004. AVO launched an overflight on January 11. The crew observed nearly continuous low-level ash and steam emission from the central cone and much of the caldera was thinly covered in ash (fig. 33).

Seismic data, web camera views, and satellite images indicated that low-level ash emissions continued for the next 5 weeks. The seismicity was characterized by low-amplitude tremor with occasional larger bursts. Weather permitting, satellite views showed anomalous heat at the summit cone consistent with hot blocks and ash ejection from the vent. The web camera showed intermittent ash clouds with the highest reaching almost to 13,000 ft (4,000 m) ASL. Strombolian eruptive activity was visible to residents of Perryville during the night of February 3. Then during the week of February 25, seismicity decreased substantially and only minor emissions of steam were observed. AVO reduced the Level of Concern from **ORANGE** to **YELLOW**. By the end of following week, volcanic tremor had subsided and seismic activity was deemed to be at background levels and the Level of Concern was reduced from **YELLOW** to **GREEN** (table 6).

Veniaminof remained relatively quiet until early September when several minor bursts of ash were observed by Perryville residents and visible on the web camera (fig. 34). This and an increase in seismicity prompted AVO to elevate the Level of Concern from **GREEN** to **YELLOW** on September 7. The minor unrest continued only for a couple of weeks when seismicity once again decreased to background level and there were no observations of emissions. AVO reduced the Level of Concern from **YELLOW** to **GREEN** on September 28.

Then on November 4, a low-level, minor ash emission visible in the webcam prompted AVO to raise the Level of Concern from **GREEN** to **YELLOW**. Slightly elevated seismicity persisted for the next few weeks but poor weather conditions precluded visual observations. By mid-December, seismic levels were again down to background levels, and on December 30, the Level of Concern was downgraded from **YELLOW** to **GREEN,** the 8th Color Code change of the year for Veniaminof (table 6).

In response to the 2005 unrest at Veniaminof, AVO staff closely monitored seismic data, and satellite and web-camera imagery. Images and other graphical and text information were made available to the public through the AVO website. AVO issued six special Information Releases on the activity at Veniaminof between January 4 and December 30, 2005.

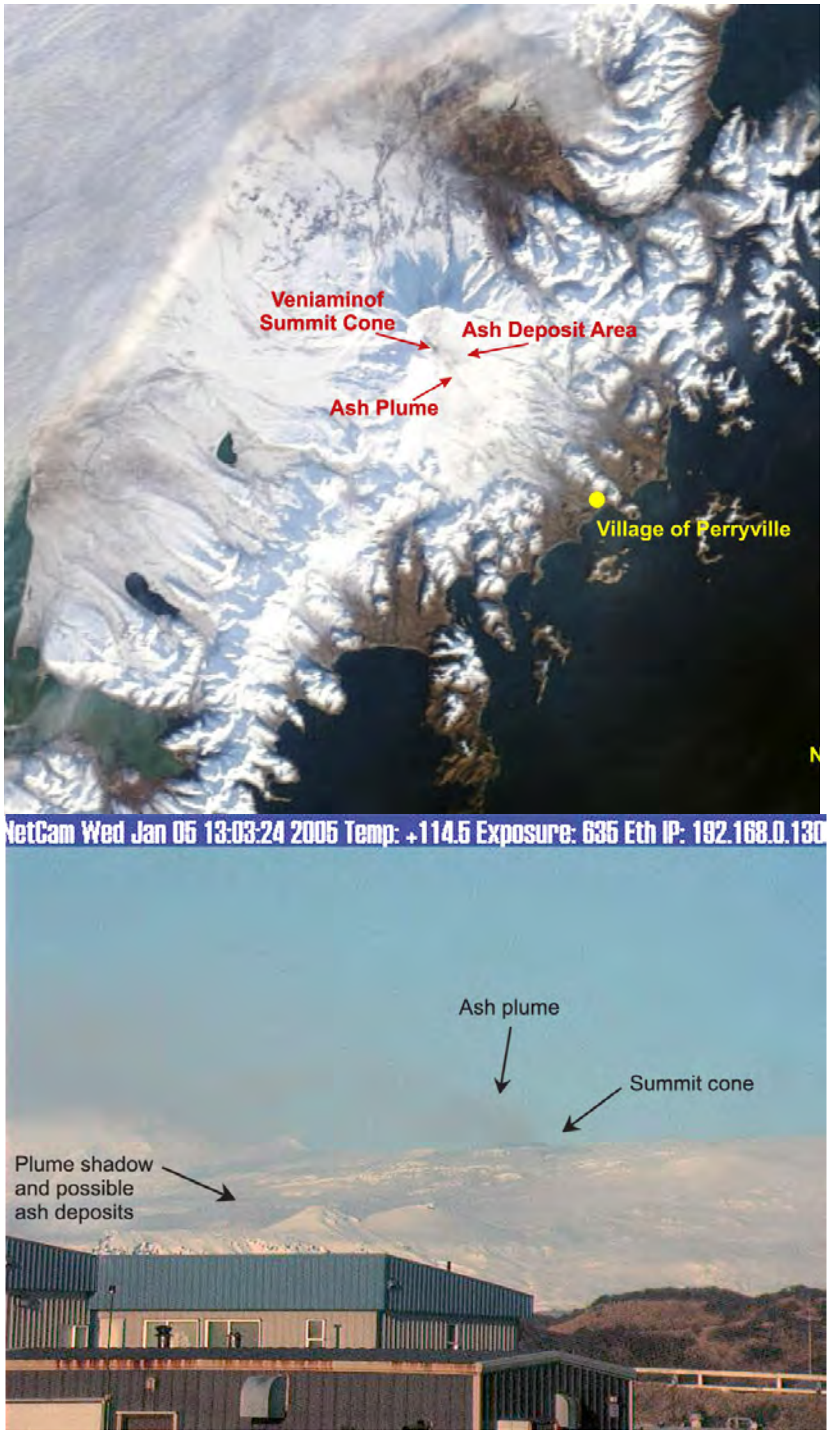


Figure 31. MODIS satellite GoddardTerra image (top) taken at 2205 UTC (1305 AST), January 5, 2005. Image displays a faint ash plume extending to the south-southeast that also was observed in the AVO web camera image from the village of Perryville (bottom) at 1303 AST, January 5, 2005. A faint area of ash deposition to the southeast across Veniaminof caldera appears in the MODIS image. Annotated images provided by Steve Smith, AVO/UAFGI.

Figure 32. Spoke-like deposits of ash across the floor of Veniaminof caldera and ash and steam emanating from the active central cone. Photograph by Pen Air pilot Ryan Hazen, taken about 11 a.m., January 7, 2005.

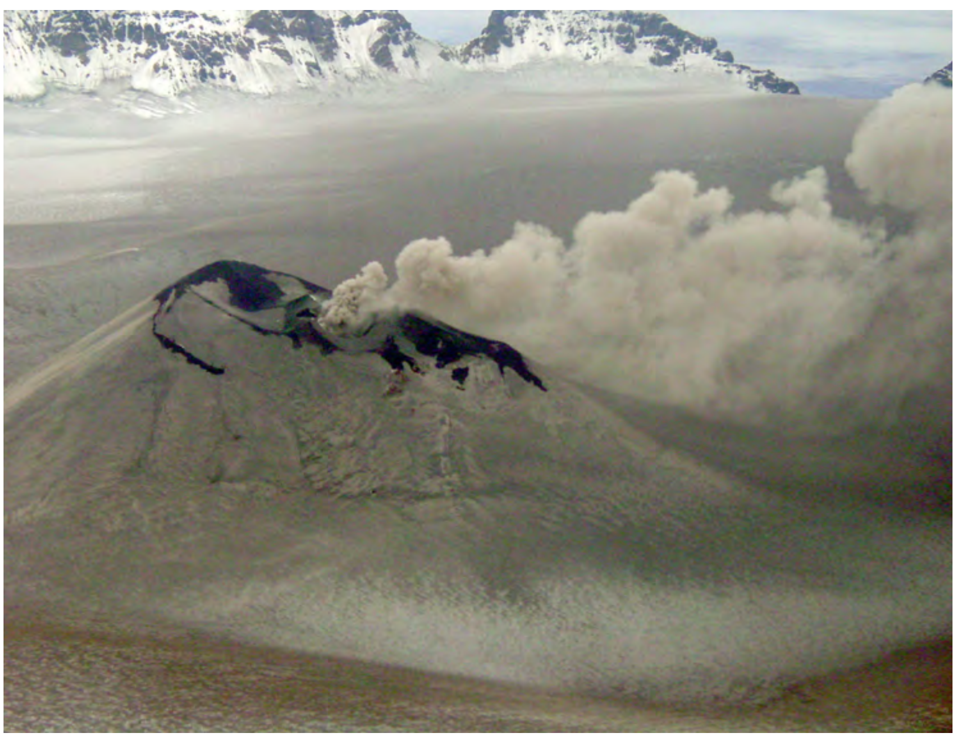


Figure 33. Continuous low-level ash and steam emission from the central intracaldera cone of Veniaminof. Most of the caldera floor is thinly covered in ash. Photograph by Kristi Wallace, AVO/ USGS, January 11, 2005.

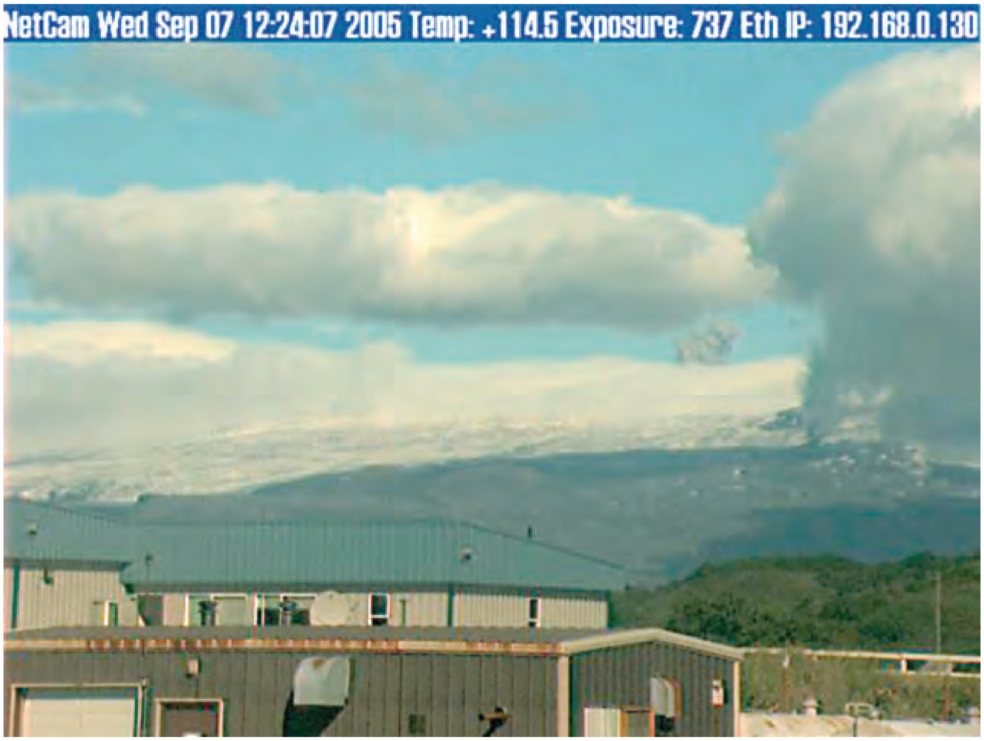


Figure 34. Small burst of ash and steam rises from the intracaldera cone of Veniaminof. Photograph is from the AVO Perryville web camera, September 7, 2005.

Veniaminof is an andesitic stratovolcano with an ice-filled, 10-km (6-mi) diameter summit caldera located on the Alaska Peninsula, 775 km (480 mi) southwest of Anchorage and 35 km (22 mi) north of Perryville (fig. 1). Veniaminof is one of the largest and most active volcanoes in the Aleutian Arc and has erupted at least 12 times in the past 200 years (Miller and others, 1998). Low-level and phreatic (?) ash explosions from the intracaldera cone occurred in 2002, 2003, and 2004 (Neal and others, 2005a; McGimsey and others, 2005b). The last significant magmatic eruption occurred in 1993–95 from the prominent cinder and spatter cone in the northwest sector of the caldera (table 7). The 1993–95 eruption was characterized by intermittent, low-level emissions of steam and ash, and production of a small lava flow that melted a pit in the caldera ice field. Previous historical eruptions have produced ash plumes that reached 6,000 m (20,000 ft) ASL and ash fallout that affected areas within about 40 km (25 mi) of the volcano.

Pavlof/Hague Volcanoes

Pavlof	Mount Hague vent of Emmons Lake Caldera
CAVW#1102-03	CAVW#1102-02
58°25′N 161°54′W 2,518 m (8,262 ft)	55°23′N 161°58′W 1,511 m (4,956 ft)
Alaska Peninsula	
SVA	
Minor steam plumes, possibly with ash	

National Weather Service personnel in Cold Bay reported a steam plume emanating from the side of Pavlof on April 16, 2005. Subsequent analysis of the photographs sent to AVO indicated that the steam cloud originated instead from adjacent Mount Hague (fig. 35), possibly from the fumarolic field located on the south flank—instead of the crater lake—based on the plume position; however, no direct observations confirmed the source. Seismicity was determined to be normal.

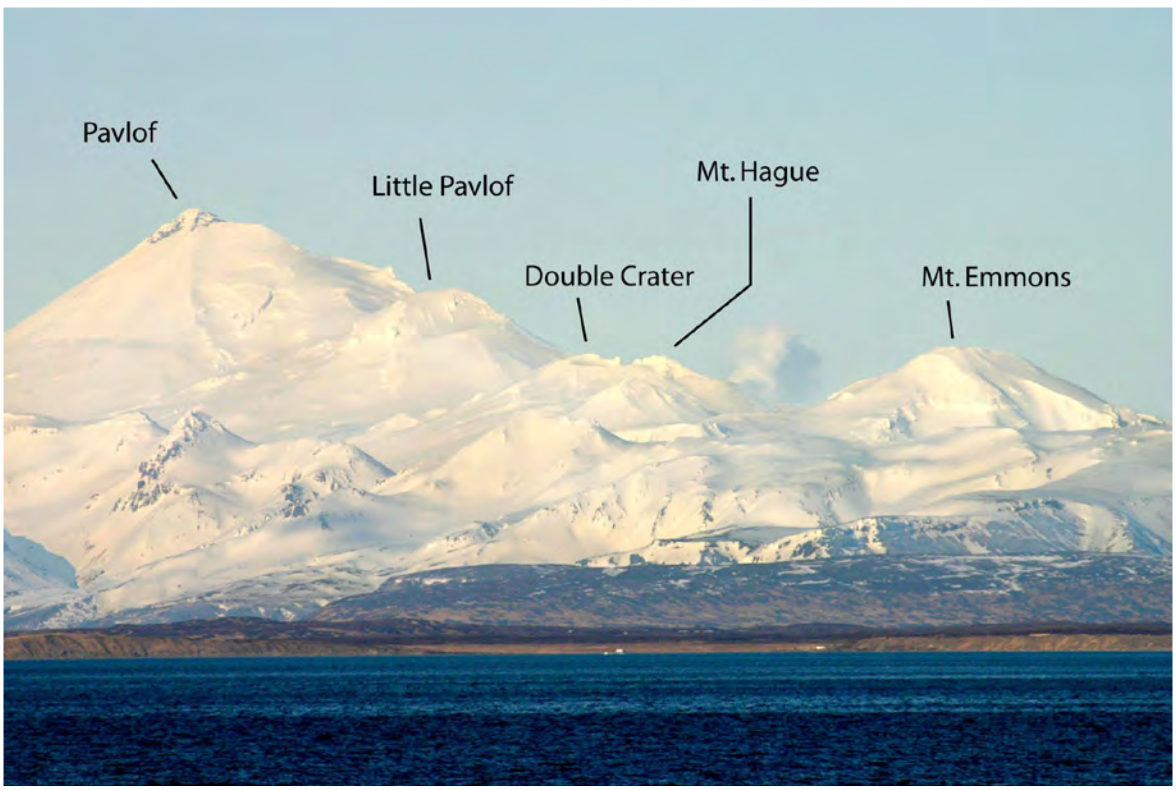


Figure 35. View of Pavlof, Little Pavlof, Double Crater, Mount Hague, and Mount Emmons, looking south. Steam appears to be originating from Mount Hague—either from Hague's crater lake, or its south flank fumarolic field. Photograph by Nathan Foster, NWS, April 16, 2005; annotated by Chris Waythomas, AVO/USGS.

On May 23 and 24, 2005, observations of steam—this time possibly containing some ash—rising to as much as 3,000 ft (~900 m) above Pavlof again were reported to AVO, as well as to FAA and AAWU. Photographs revealed that the plume originated instead from Mount Hague (fig. 36). Analysis of satellite images revealed no evidence of ash, and no unusual seismicity was recorded. One of the two summit craters on Mount Hague contains vigorous fumaroles and has produced strong steam emissions in previous years (table 7). The activity was interpreted to result from normal fluctuation of the hydrothermal system at Mount Hague and was reported in the AVO Weekly Update on May 27, 2005.

Pavlof, the dominant volcanic peak in the area, is considered Alaska's most historically active volcano with 40 relatively well-documented eruptions since 1790 (Miller and others, 1998). The Fuji-like symmetrical stratocone is located 60 km (37 mi) northeast of Cold Bay at the tip of the Alaska Peninsula, adjacent to the Holocene Emmons Lake Caldera complex. The last eruption occurred during September 1996–January 1997 and was characterized by spectacular Strombolian fire fountaining that fed a blocky lava flow down the southwest flank (table 7). In recent years, steaming at Mount Hague has often been mistakenly attributed to Pavlof.

Mount Hague is a post-caldera, double-peaked stratocone located within Emmons Lake Caldera, situated adjacent to Pavlof Volcano. Although no historical eruptions are attributed to this vent, one of the two summit craters hosts an ephemeral lake underlain by vigorous fumaroles that are known to occasionally produce robust steam plumes (table 7). A south-flank fumarolic field also may be capable of producing anomalous steam clouds.

Figure 36. A prominent steam plume rises from Mount Hague as viewed over a building in Cold Bay. Photograph by Lee Robertson, NWS, May 24, 2005.

Shishaldin Volcano

CAVW #1101-36

54°45′N 163°58′W
2,857 m (9,373 ft)

Unimak Island, eastern Aleutian Islands

SVA; INCREASED SEISMICITY AND STEAMING

Small steam plumes prompt pilot reports

Following more than a year of relative quiescence, on December 22, 2005, a pilot reported a steam plume rising 3,000 ft above the summit of Shishaldin. The FAA issued an Urgent Pilot Report. Commensurate with this report, a few small explosions signals were recorded on the pressure sensor located on the north flank. AVO seismologists also noted that the amplitudes of seismic events had increased since about mid-November. Because no ash apparently was released and the activity did not continue, AVO did not issue a formal information release nor increase the level of concern color code.

The background level of seismic activity at this frequently active volcano has remained relatively high since its last eruption—in 1999—and consists of many small, discrete, volcano-tectonic earthquakes, small explosion signals, and short (2–6 min) periods of tremor-like signals. Typically, this activity is interpreted to reflect either hydrothermal or magmatic processes occurring high in the conduit and deep in the summit crater of Shishaldin (Caplan-Auerbach and Petersen, 2005). The volcano was restless for much of 2004 (Neal and others, 2005b).

Shishaldin Volcano, located about 1,100 km (~680 mi) southwest of Anchorage, near the center of Unimak Island, is a symmetric stratocone that forms the highest peak in the Aleutian Islands (fig. 37). Largely basaltic in composition, Shishaldin is one of the most active volcanoes in the Aleutian arc with at least 27 eruptions since 1775 (Miller and others, 1998). The most recent eruptive period began in mid-February 1999, and produced a sub-Plinian ash cloud to at least 45,000 ft ASL on April 19, 1999 (Nye and others, 2002). During subsequent Strombolian eruptions, ash plumes as high as 6 km (20,000 ft) ASL extended as far as 800 km (500 mi) from the volcano. The last eruptive activity occurred on May 27, 1999; however, continued phreatic activity giving rise to intermittent seismicity and significant steam plumes containing minor amounts of ash persists. Even during noneruptive periods, nearly constant fumarolic activity within the summit crater produces a steam plume that occasionally can be quite vigorous and typically results in numerous false eruption reports. The nearest community is False Pass, 32 km (20 mi) east-northeast of the volcano.

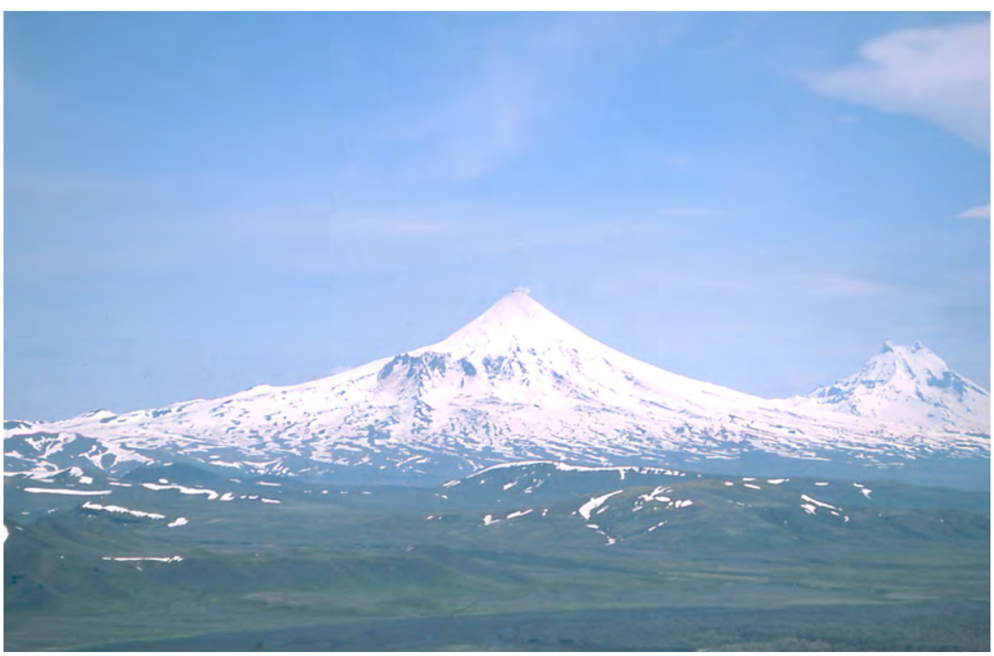


Figure 37. Shishaldin (left) and Isanotski (right) Volcanoes on Unimak Island. Shishaldin, a Fuji-like, nearly symmetrical stratovolcano, is the highest peak in the Aleutian Islands (2,857 m [9,373 ft]) and is one of the most frequently active volcanoes in Alaska. Photograph by Game McGimsey, AVO/USGS, June 27, 2000.

Cleveland Volcano

CAVW #1101-24

52°49′N 169°57′W
1,730 m (5,676 ft)

Chuginadak Island, east-central Aleutian Islands

SVA; MINOR ERUPTION

Thermal anomalies, PIREP, ash on snow; ash cloud to 15,000 ft; mild Strombolian activity

After several years of quiescence following an explosive eruption in 2001, AVO remote sensors observed a 3-pixel thermal anomaly at the summit of Cleveland on March 13, 2005 (fig. 38). On April 27, 2005, the FAA alerted AVO of a pilot report of eruptive activity—“ash cloud…15,000 to 18,000 ft high”—in the vicinity of Cleveland (based on coordinates from the pilots). Satellite images showed no evidence of activity. AVO seismologists checked seismic data from the nearest stations (Nikolski, located 75 km [45 mi] east, and at Okmok Volcano, 150 km [93 mi] east of Cleveland), and found nothing unusual. CWSU issued a one-time Urgent Pilot Report, and AAWU issued a one-time SIGMET. Although time-series thermal data did not record any evidence of activity, short-lived minor explosive activity would not be considered unusual for Cleveland and could go undetected if it occurred during periods between acquisitions of satellite images or if concealed within the frequent cloud cover.

Following the detection of a 1-pixel thermal anomaly at the summit on June 28, evaluation of before and after satellite images suggested the presence of a lahar deposit on the northeast flank, inferring that minor activity persisted at Cleveland. Then, on July 5, the entire upper flanks of the volcano were observed dusted with ash in a satellite image (fig. 39). AVO raised the Level of Concern Color Code from **UNASSIGNED** (**UA**) to **YELLOW** in an Information Release on July 7, 2005 (table 6). The presence of ash, minor blocky avalanche-like deposits, and thermal anomalies was consistent with low-level Strombolian eruptive activity (D. Schneider, AVO logs).

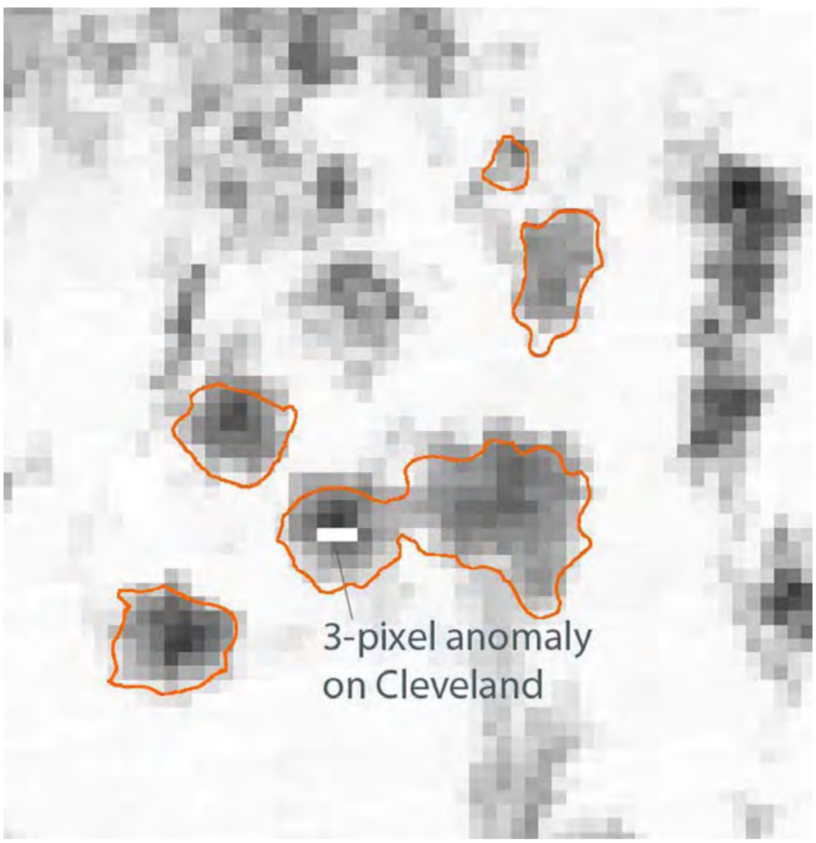


Figure 38. MODIS Band 20 (mid-infrared) satellite image of a 3-pixel thermal anomaly observed at the summit of Cleveland Volcano on March 13, 2005. Islands are outlined in red. Image provided by Steve Smith, AVO/UAFGI.

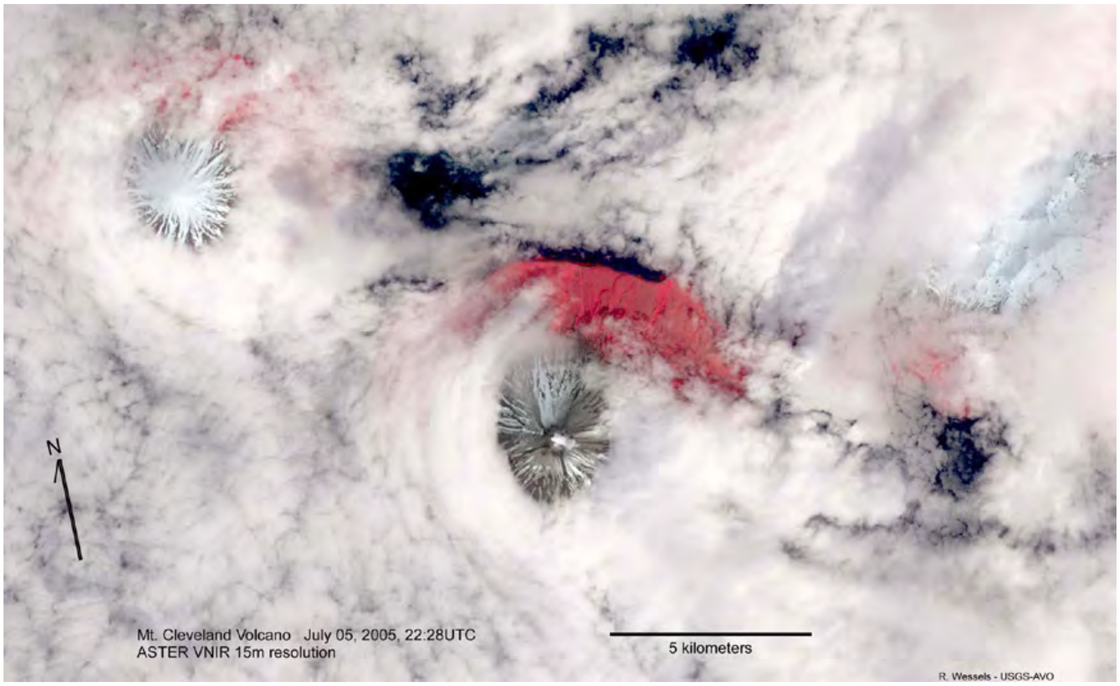


Figure 39. ASTER VNIR satellite image from July 5, 2005, shows that the summit of Mount Cleveland (center of image) has been partially dusted by a light coating of ash on top of the snow (red denotes healthy vegetation in VNIR images). There also are some darker bands extending from the summit that may be small debris flows. The nearby summit of Carlisle is still snow white. The image also shows a small steam plume coming from the Cleveland summit crater. Image provided by Rick Wessels, AVO/USGS.

Thereafter, although a thermal anomaly was observed on August 11, the activity appeared to wane. AVO reduced the Color Code from **YELLOW** back to **UA** on August 27. But the volcano remained restless, and a summit thermal anomaly again was observed on August 31. By mid-September, AVO was ready to test a new automated system that detects thermal anomalies and raises an alert. On September 21, this new system successfully detected a thermal anomaly at the summit of Cleveland. For the next few weeks, the volcano remained quiet. Then, on the morning of October 7, AVO detected in satellite images a small drifting ash cloud located about 150 km (90 mi) east-southeast of Dutch Harbor. On the basis of regional seismic data at Nikolski (75 km [45 mi] east of the volcano), and backtracking the ash cloud, AVO concluded that a small eruption had occurred at Cleveland at approximately 01:45 ADT (0945 UTC). AVO and the NWS worked together to determine that the ash cloud was at an altitude of no more than 15,000 ft. (4,600 m). No ash fell in Nikolski. AVO immediately raised the Color Code from **UA** to **ORANGE** and NWS issued a SIGMET indicating that the ash cloud was moving east. The next day, October 8, there was no sign of ash emission or a summit thermal anomaly, and on October 10 the Color Code was downgraded from **ORANGE** to **YELLOW**. The last thermal anomaly was seen on November 6, and steam plumes were occasionally visible in satellite data for the next several weeks. Because there was no evidence of ash emissions on November 25, AVO reduced the Color Code for Cleveland from **YELLOW** to **UA**. As fate would have it, a few days later, evidence for minor eruptive activity was observed; however, the activity did not continue and the volcano remained quiet for the rest of the year. AVO issued five special Information Releases about Cleveland activity between July 7 and November 25, 2005.

Cleveland Volcano forms the western half of Chuginadak Island, a remote and uninhabited island in the east central Aleutians. It is located about 75 km (45 mi) west of the community of Nikolski, and 1,500 km (940 mi) southwest of Anchorage. No seismic instrumentation exists at the volcano and the nearest seismic station is located in Nikolski. Documented historical eruptions at Cleveland Volcano have been characterized by short-lived explosive bursts of ash, occasionally accompanied by lava fountaining, lava flows, and debris flows down the flanks. In February 2001, Cleveland had three explosive events that produced ash clouds as high as 12 km (39,000 ft) above sea level. That eruption also produced a rubbly lava flow and hot avalanche that reached the sea (table 7; Dean and others, 2004).

Korovin Volcano (Atka)

CAVW #1101-16

52°23′N 174°09′W
1,533 m (5,030 ft)

Atka Island, west-central Aleutian Islands
SMALL STEAM AND MINOR ASH ERUPTION; ANOMALOUS SEISMICITY

On the morning of February 24, 2005, AVO received a report from residents of Atka Village that Korovin had erupted the previous evening, producing a large steam and ash cloud. February 23 was a clear day and local residents had noticed minor steaming from Korovin about noon (fig. 40). Then, about 7 p.m. HST (8 p.m. AST), they witnessed a dark plume over Korovin, rising several thousand feet high, drifting east, that had ash visibly falling out near the base, presumably confined to the flanks of Korovin (fig. 41). Several minutes later, three or four smaller, gray puffs occurred. Although they watched, no further activity ensued during the calm, clear, moonlit night.

Satellite data from about the time of the reported activity indicated the presence of a 1–2 pixel thermal anomaly and a small steam plume, possibly with localized minor ash. Height of the steam plume was estimated to be about 10,000 ft (~3 km), corroborating the observer account. AVO issued an Information Release on February 24 and raised the Level of Concern Color Code to **YELLOW**. With no further reports of continuing activity, nothing evident in subsequent satellite data, and no unusual seismicity from a seismic station in Atka Village, AVO reduced the Color Code from **YELLOW** to **UA** in the March 4, 2005, Weekly Update (table 6). Evidence of similar activity has been identified in 2002 and 2004 satellite images and observed by field crews in 2004 (fig. 42).

Figure 40. Steam rising above Korovin Volcano (on far left skyline) on northern Atka Island about noon on February 23, 2005, a prelude to a minor eruption later that day. View is from Atka Village. Photograph courtesy of Louis and Kathleen Nevzoroff.

Figure 41. Steam plume developing over Korovin Volcano at about 7 p.m. on February 23, 2005, and drifting eastward. Ash was observed falling locally out of the base of the cloud. View is from Atka Village. Photographs courtesy of Louis and Kathleen Nevzoroff.

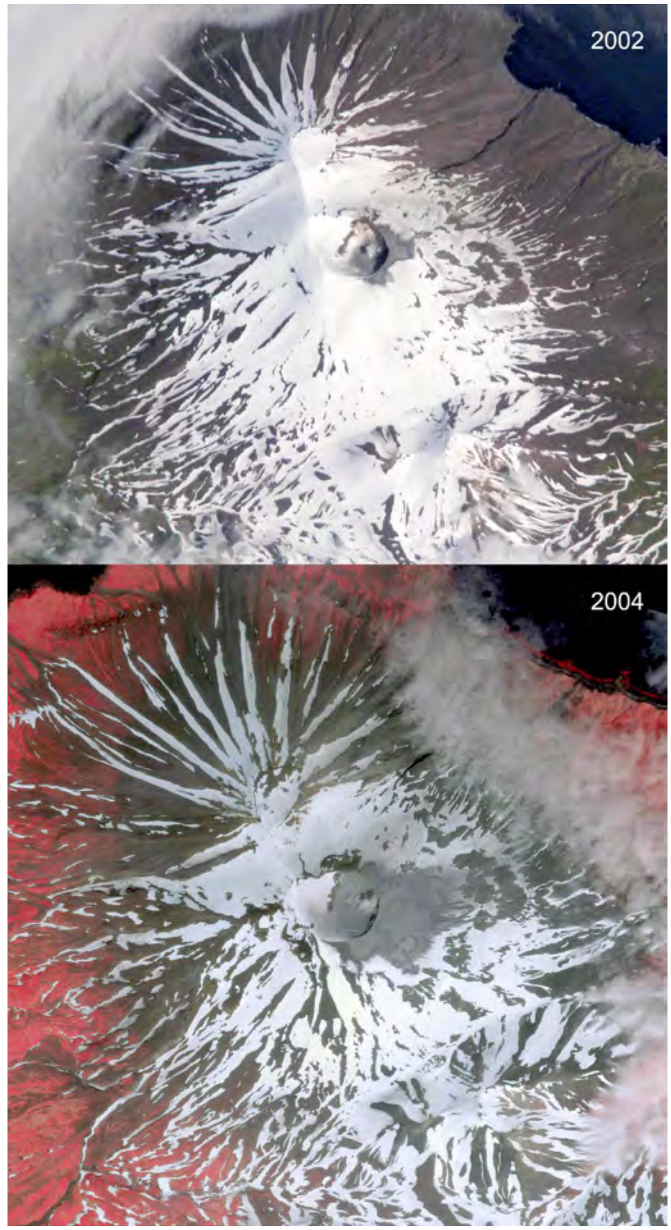


Figure 42*A*. Satellite photographs showing ash deposits on the upper east flank of Korovin Volcano in 2002 (top) and 2004 (lower). Intermittent, minor phreatic eruptions through a hot, roiling lake in the south summit crater of Korovin are the probable source. Top image July 5, 2002, courtesy of the Image Analysis Laboratory, NASA Johnson Space Center, Mission ISS005, E Frame 6898; bottom image July 4, 2004, Ikonos near-infrared color composite, Copyright Space Imaging LLC.

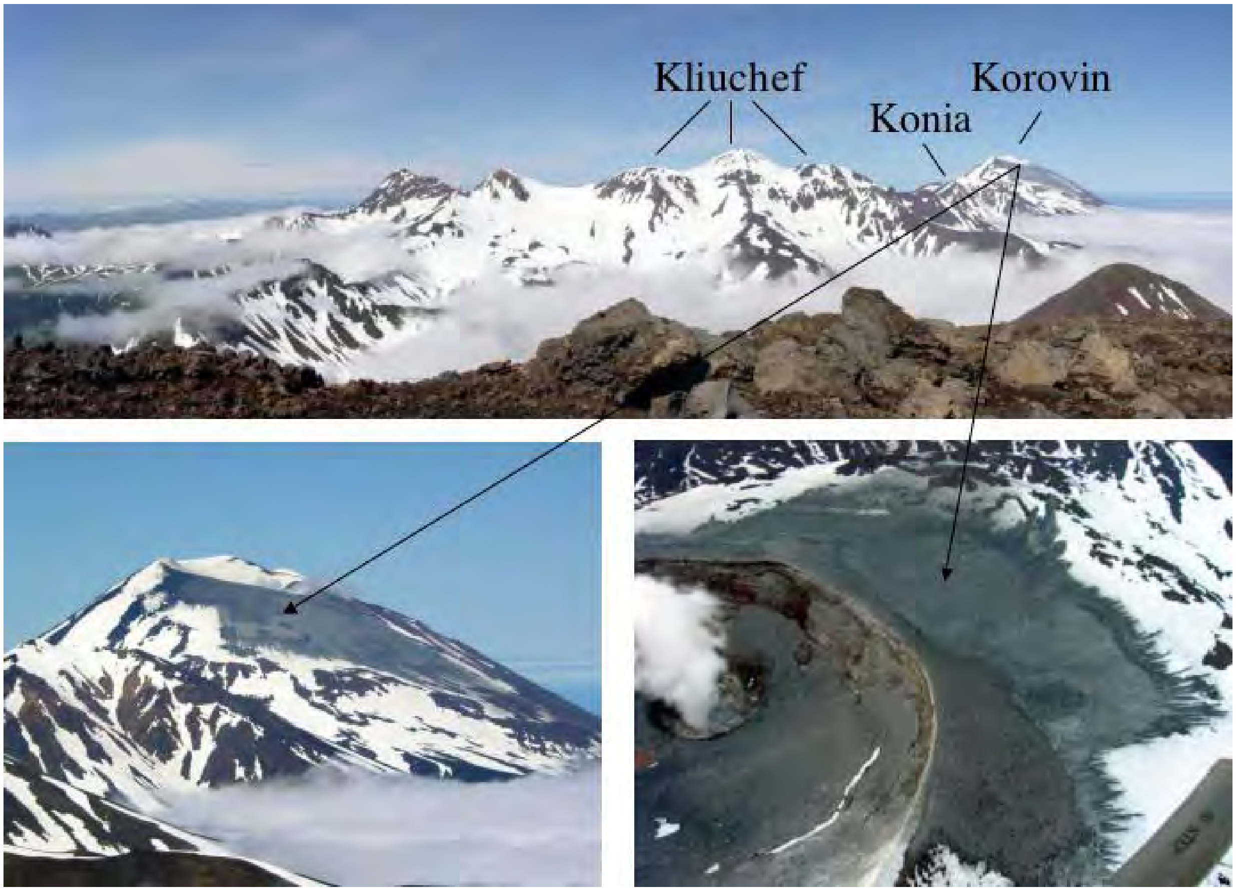
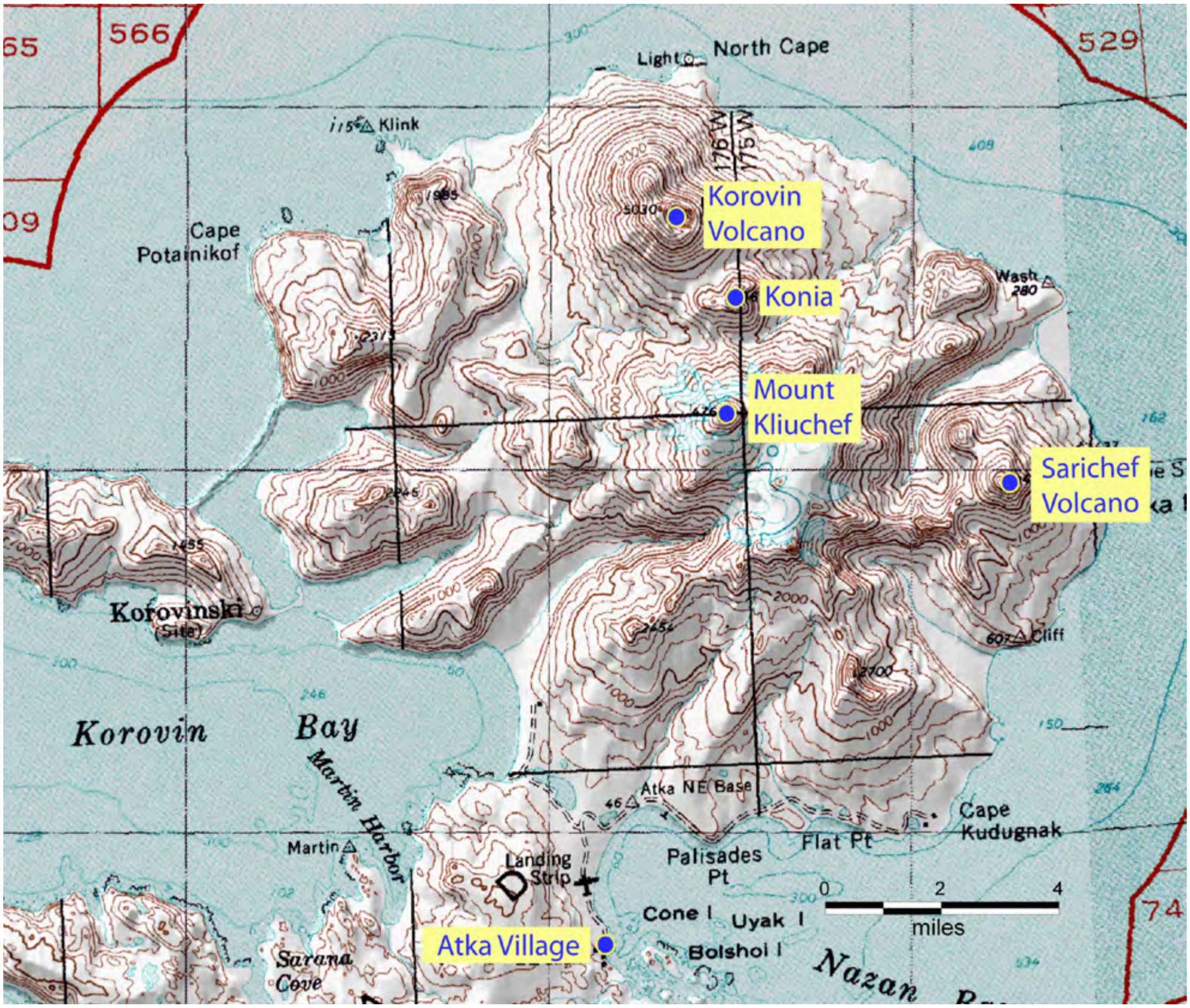


Figure 42*B*. Views of ash deposit on the upper east flank of Korovin. Top photograph by Game McGimsey, AVO/USGS, July 11, 2004. Lower left: View of Korovin from summit of Sarichef (see fig. 43 for location). Photograph by Game McGimsey, AVO/USGS, July 11, 2004. Lower right: Aerial view of Korovin's active summit crater and ash deposits on upper east flank. Photograph by Jackie Caplan-Auerbach, AVO/USGS, June 2004.

A PIREP of steam reaching several thousand feet above Korovin on March 19 was the next report of activity, and then in early May observational data indicated that the lake had drained in the south summit crater of Korovin and that incandescence was visible in the about 100-m (~325 ft)-wide pit. The next several months were quiet. Then, on September 13, 2005, a long sequence of strong seismicity was recorded on the newly operational Korovin seismic network. The sequence began with two small local events followed by about 30 minutes of weak tremor, and then about 20 weak local events. Nothing unusual was detected on satellite images of the time period.

Although a network of seismic stations was installed on northern Atka Island during the summer of 2004, data were not accessible until early March 2005, and Korovin was not considered to be seismically monitored until late in 2005—announced in the December 2, 2005, Information Release—when a sufficient period of background seismicity had been recorded, and equipment/communications problems resolved (table 1). On December 2, Korovin, which previously had been listed as **UA**, was formally assigned Color Code **GREEN**.

Korovin is one of several stratovolcanoes that forms the northern peninsula of Atka Island in the Central Aleutians, 1,760 km (1,100 mi) southwest of Anchorage and 540 km (330 mi) west of Dutch Harbor (fig. 43). The village of Atka lies 21 km (13 mi) south of Korovin. The volcano has two summit craters, of which the southern crater contains a small, roiling, heated lake and is presumed to have been the source of the most recent historic eruptive activity (June 1998), as well as minor phreatic bursts such as reported above (table 7, fig. 42). Prior to this, the last reported eruption at Korovin was in March 1987. In the last 200 years, eruptions and possible eruptions attributed to Korovin occurred in 1907, 1951, 1953, 1954, 1973, 1976, 1986, 1987, 1996, and 1998 and produced minor amounts of ash and a few, small lava flows (Miller and others, 1998; McGimsey and others, 2003; table 7). The 1998 eruption produced an ash cloud reported to have reached 30,000 ft (~9,100 m) ASL. Numerous fumaroles and warm mud springs occur around the western and southern flanks of Korovin, and the area is considered to be one of the most robust hydrothermal systems in the Aleutian arc.



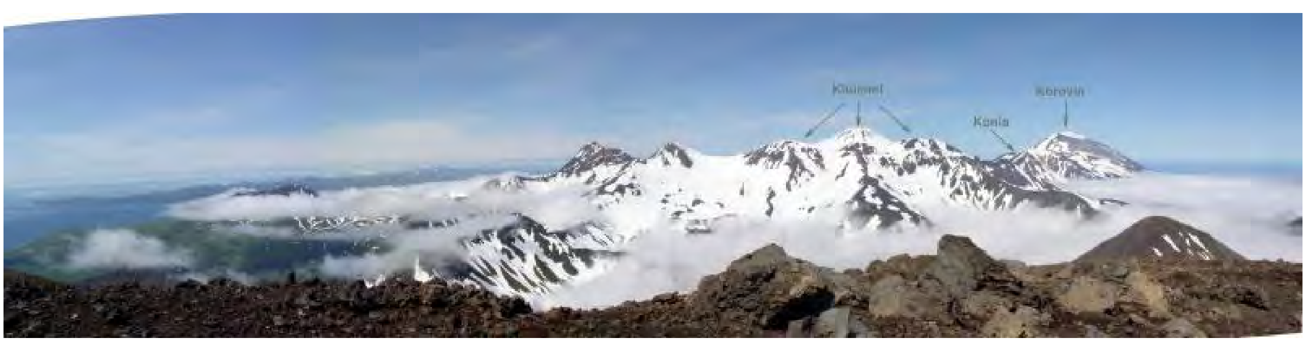


Figure 43. Locations of volcanoes on northern Atka Island. Map by Cheryl Cameron, AVO/AKDGGS. View in the photograph is from the summit of Sarichef. Note in the photograph that the upper east flank of Korovin is covered in ash, which likely was deposited during a small phreatic eruption similar to that, which occurred February 23, 2005. Photograph by Game McGimsey, AVO/USGS, July 11, 2004.

Kasatochi Volcano

CAVW #1101-13
52°11′N 175°30′W
314 m (1,030 ft)
Kasatochi Island, west-central Aleutian Islands
SVA
Change in crater lake activity

In late July 2005, AVO was contacted by Vern Byrd of U.S. Fish and Wildlife Service (USFWS)/Homer who passed along a report from a USFWS field camp on Kasatochi Island, located about 50 km (~30 mi) east of Great Sitkin and about 100 km (~60 mi) west of Korovin Volcano. On June 23, members of the field party viewed the lake and noticed nothing unusual. Then, on July 27, the same field party peered into the summit crater from the rim and saw the lake "simmering, not quite a roiling boil, concentrated in a few patchy areas, bubbling more violently in the western half of the lake….lake appeared thin (sic), no steam observed at all." The bubbling areas were intermittent. The observers did not feel vibrations or earthquakes or hear anything odd, nor did they detect unusual odors or water discoloration (the lake typically is turbid and turquoise in color). Gulls landed unperturbed on the water surface. The observers concluded that what they were seeing was a distinct change from the previous month and from conditions present during the past several years on the island.

Biologists visited the crater rim again on August 1 and reported no significant change from the activity reported on July 27. They mentioned that the lake was perhaps "simmering a little less with less area of the lake affected." A check of satellite imagery for any sign of thermal anomaly or other change during this time period came up negative, however clear views of this frequently cloud-covered small island were few (ASTER, Landsat, R. Wessels, USGS/AVO, oral commun., 2005).

A USGS-contracted helicopter in Adak transported an AVO geologist and the USFWS field party chief Brie Drummond to Kasatochi on September 2 to investigate. Winds were high and fog and clouds intermittently obscured the summit crater rim. During one low pass over the lake, no signs of bubbling or upwelling were observed. Two patches of brown scum 2–3 m (6.5–10 ft) across floated in the approximate area where bubbling was observed earlier in the summer (fig. 44). No signs of recent lake level disturbance or hydrothermal activity were noted.

Figure 44. Brown scum patches floating on the surface of the summit crater lake of Kasatochi mark the approximate areas of bubbling observed in July and August 2005 by a USFWS field crew. Photograph by Christina Neal, AVO/USGS, September 2, 2005.

Kasatochi Island is the emergent summit of a remote, 400-m (~1,300 ft)-high submarine volcano located at the northern end of a 15-km (9-mi)-long, 6-km (4 mi)-wide submarine ridge in the Central Aleutians about 840 km (~520 mi) west-southwest of the tip of the Alaska Peninsula. The cone measures approximately 2.6 × 3 km (1.6×2 mi) and has a central lake-filled summit crater about 0.8 km (0.5 mi) in diameter (figs. 45 and 46). The surface of the lake was estimated to be about 15 m (50 ft) above sea level in 2005 (C.A. Neal, U.S. Geological Survey, written commun., 2005). Historical eruptive activity is poorly known. The island was reported as "emerging" in 1760 by Greywingk and others (2003), and reported as "smoking" in 1827 and 1828.

Figure 45. View of the southeastern rim of the lake-filled summit crater of Kasatochi Volcano. Photograph by Brie Drummond, USFWS, August 14, 2004.

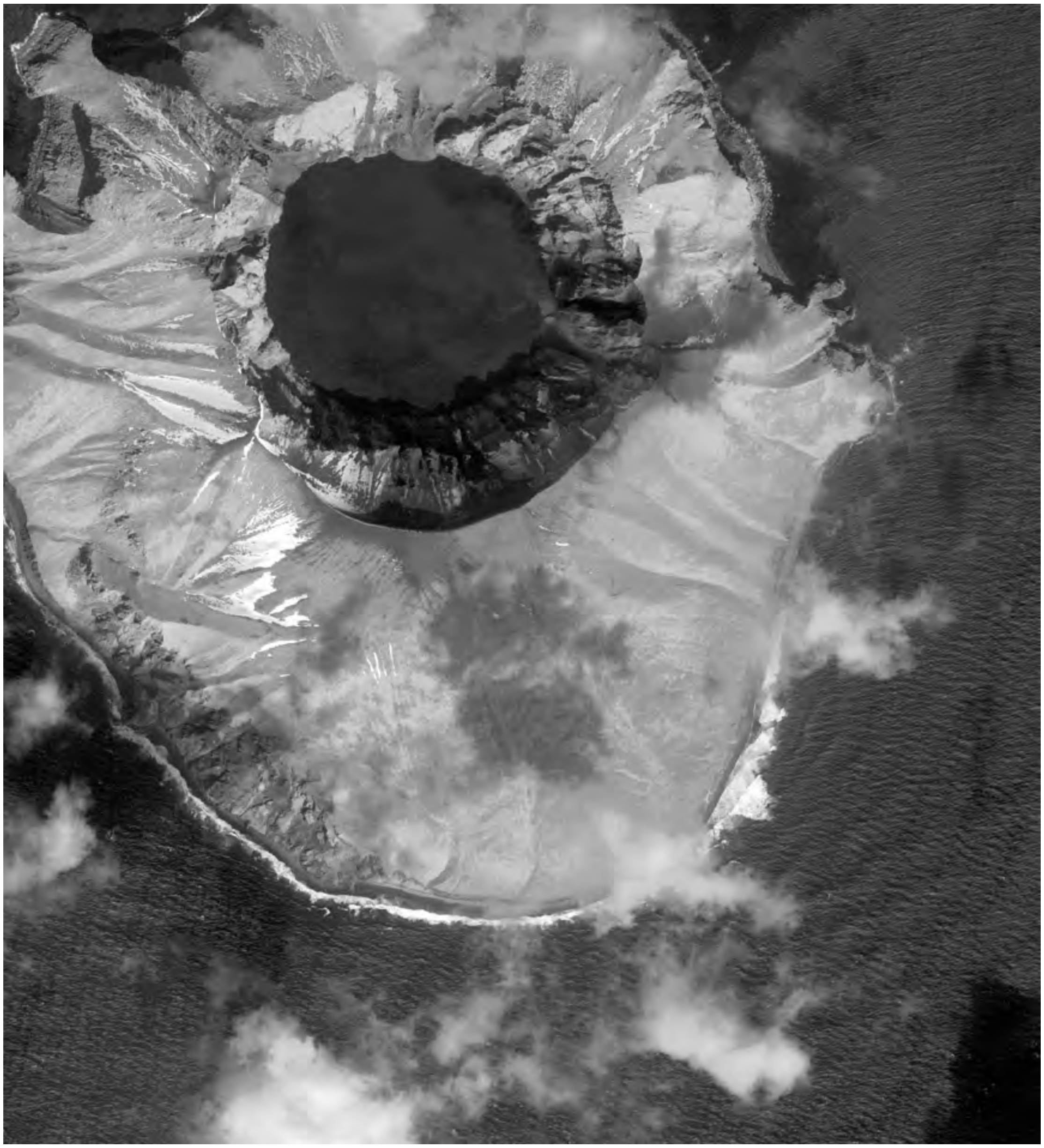


Figure 46. QuickBird satellite image of Kasatochi Volcano taken on April 9, 2004, UTC 224559. The island is 2.6 × 3 km (1.6 × 3 mi), and the crater lake is 0.8 km (0.5 mi) across. Image 771030_01_P001. Copyright Digital Globe, 2004. North at top.

Tanaga Volcano

CAVW #1101-08

51°53′N 178°08′W
1,806 m (5,926 ft)

Tanaga Island, western Aleutian Islands
SVA
Increased seisimicity, continuous tremor

Earthquake activity at Tanaga increased abruptly on October 1, 2005. Over the next several days, the number of located events ranged from 15 to 68 per day, in striking contrast to the typical one earthquake per month previously recorded since the seismic network was installed in 2003. The earthquakes centered a few kilometers northeast of the summit of Tanaga at a depth of 10–20 km (~6–12 mi), and the largest event had a magnitude of 1.7. AVO issued a special Information Release on October 5 to announce the activity. The activity further escalated that day and again early on October 7 with located earthquakes of magnitude 0.5–1.9 shallowing to depths of 6–12 km (~4–7.5 mi) beneath Tanaga's summit. This change in activity prompted AVO to raise the Level of Concern Color Code from **GREEN** to **YELLOW** on October 7, 2005. By the following week, the daily earthquake count had fallen slightly, and by the next week, earthquake activity had diminished further, but remained above background levels. A several-minute-long period of unusual seismicity occurred on October 17 and may have been a landslide or small phreatic explosion, but no signs of activity were visible in satellite images. Although the daily earthquake count continued to dwindle, nearly continuous, weak volcanic tremor was recorded on seismic stations closest to nearby Takawangha Volcano on October 24 (fig. 47). This was the first episode of tremor recorded at the Tanaga cluster since the seismic network was installed in 2003. Weak tremor continued for next several weeks, gradually declining. Seismicity continued to decline further during November, and by the end of the month the likelihood of an eruption was considered significantly decreased. In an Information Release issued on November 25, 2005, AVO reduced the Level of Concern Color Code from **YELLOW** to **GREEN**.

Tanaga Island lies in the Andreanof Islands approximately 100 km (62 mi) west of the community of Adak and 2,025 km (1,260 mi) southwest of Anchorage. Tanaga is the highest of three closely spaced, east-west aligned stratovolcanoes that make up the northwest end of Tanaga Island (fig. 47). The last reported eruption of Tanaga occurred in 1914 and earlier eruptions were reported in 1763–70, 1791, and 1829 (Miller and others, 1998). Reports of these eruptions are vague, but deposits on the flanks of the volcano show that typical eruptions produce blocky lava flows and occasional ash clouds. Eruptions have occurred both from the summit vent and a 1,584 m (5,197 ft)-high satellite vent on the volcano's northeast flank. Immediately west of Tanaga Volcano lies Sajaka, a 1,354 m (4,443 ft)-high compound edifice with an older cone to the east that collapsed into the sea within the last few thousand years, and a new cone that has grown in the breach. The new cone is 1,312 m (4,305 ft) high and consists of steeply dipping, interbedded cinder deposits and thin, spatter-fed lava flows. Takawangha lies to the east of Tanaga, which is separated from the other active volcanic vents by a ridge of older rock. Takawangha's 1,449 m (4,754 ft)-high summit is mostly ice-covered, except for four young craters that have erupted ash and lava flows in the last few thousand years. Parts of Takawangha's edifice are altered hydrothermally and may be unstable, and could produce localized debris avalanches. No historical eruptions are known from Sajaka or Takawangha; however, fieldwork shows that recent eruptions have occurred and it is possible that historic eruptions attributed only to Tanaga instead may have come from these other vents (Coombs and others, 2007).

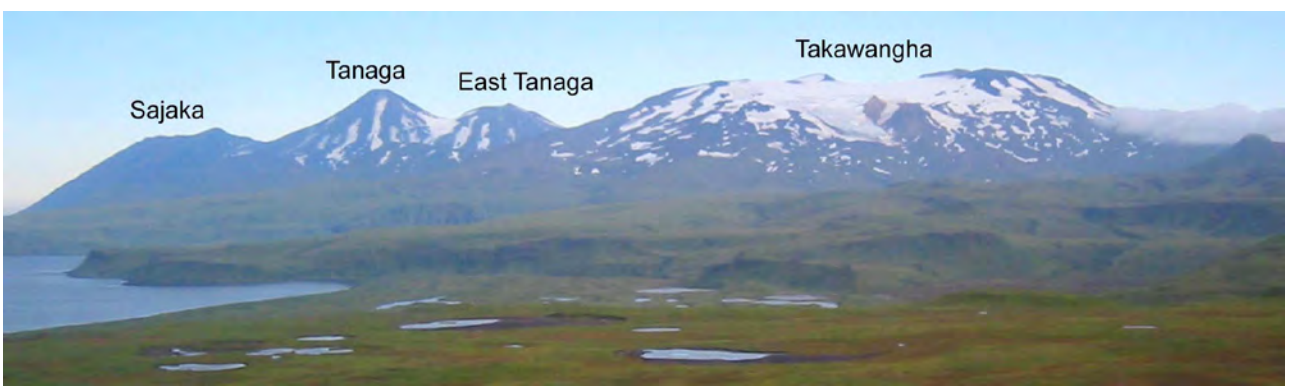


Figure 47. Index map and photograph of the northwestern part of Tanaga Island showing the east-west aligned Tanaga cluster—Sajaka, Tanaga, and East Tanaga. Takawangha is a somewhat older volcano that has erupted ash and lava flows in the last several thousand years (Coombs and others, 2007). Map and photograph by Michelle Coombs, AVO/USGS, August 2003.

Volcanic Activity in Russia, 2005 Volcanic Activity, Kamchatka Peninsula, and the Northern Kurile Islands, Russia

Active volcanoes on Russia's Kamchatka Peninsula pose a serious threat to aircraft in the North Pacific (fig. 3). Since the mid-1990s, by agreement with the Institute of Volcanic Geology and Geochemistry (IVGG) and the Kamchatka Experimental and Methodical Seismology Department (KEMSD, Geophysical Service), both Institutes of the Russian Academy of Sciences in Petropavlovsk-Kamchatsky, AVO assists with global distribution of information about eruptions in Russia (Kirianov and others, 2002). In the spring of 2004, a reorganization of Russian scientific institutes occurred and IVGG became part of the new Institute of Volcanology and Seismology (IVS), also of the Russian Academy of Sciences. The Kamchatkan Volcanic Eruption Response Team (KVERT), now consisting of scientists from IVS and KEMSD, continues to issue through email a weekly information release that is rebroadcast by AVO to our web site and to recipients by facsimile. When volcanic activity intensifies at any Kamchatkan Volcano requiring notification of aviation and other interests, KVERT sends additional updates as needed.

Scientists with the KEMSD monitor most of the frequently active volcanoes in Kamchatka with one or more short period seismometers (fig. 48, table 9). In addition, KVERT and KEMSD receive visual reports of activity from scientific observers in the communities of Klyuchi (population about 10–15,000, ~45 km [~28 mi]) southwest of Sheveluch) and Kozyrevsk (population about 2–3,000, ~50 km [~31 mi]) west of Klyuchevskoy) to the north and west of the Klyuchevskaya group of volcanoes. On occasion, KVERT also receives reports from scientific observers near Karymsky Volcano, and pilot reports are increasingly available from the local Civil Aviation Meteorological Center at Yelizovo Airport near Petropavlovsk. Near real-time web camera images of Sheveluch, Klyuchevskoi, and Bezymianny Volcanoes also are part of the routine monitoring data used by KVERT and AVO. On the northern Kurile island of Paramushir, KVERT receives weekly reports from scientists in the town of Severo–Kurilsk. A single, regional, short-period seismometer in Severo–Kurilsk provides limited seismic data for the nearby Ebeko and Chikurachki Volcanoes (fig. 48).

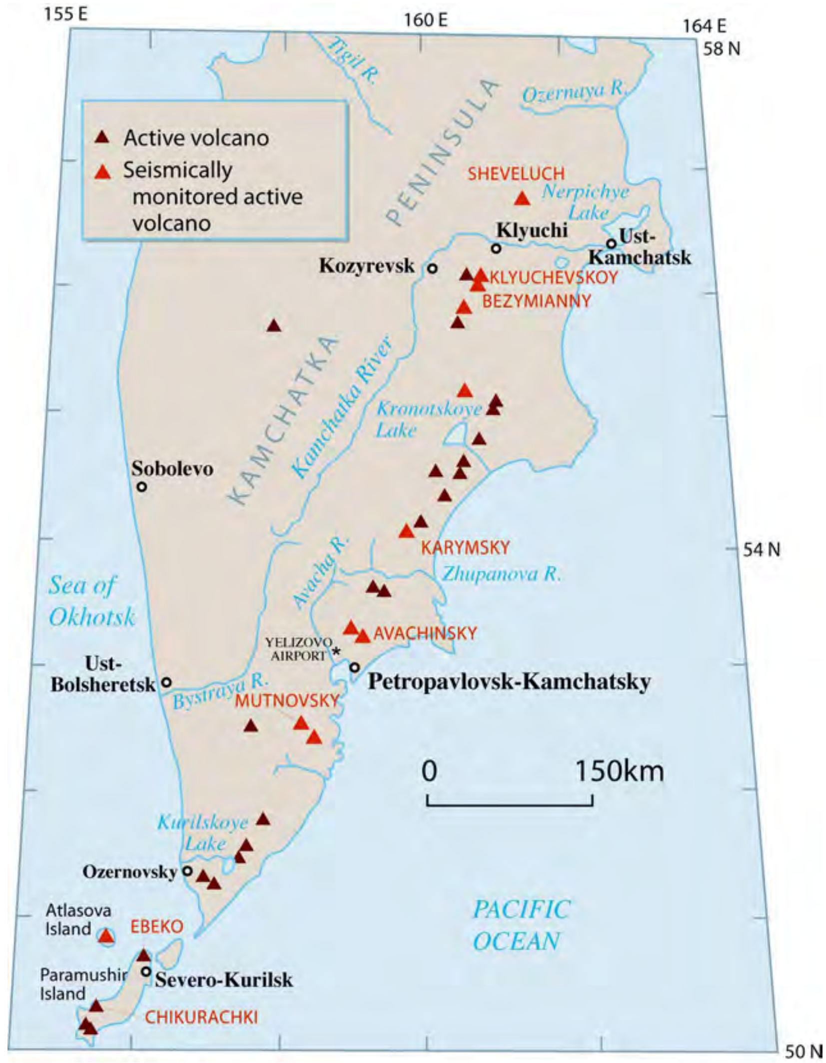


Figure 48. Kamchatka Peninsula and active volcanoes of concern. Volcanoes mentioned in this report are shown in red. Seismically monitored volcanoes are shown with a red triangle.

Table 9. Seismically monitored volcanoes of Kamchatka as of December 2005.

[Compiled by Sergey Senyukov, Kamchatka Experimental and Methodical Seismology Department (KEMSD), and C.A. Neal, Alaska Volcano Observatory. Prior to 1979, other Russian scientific institutes maintained programs of volcano monitoring in Kamchatka (a partial listing includes: 1961–71, Pacific Seismological Department of Institute of Earth Physics; 1972–78, Institute of Volcanology)]

Volcano	Approximate start date of continuous seismic monitoring by KEMSD	Other monitoring techniques used routinely
Sheveluch	Seismic station – February 1987; Telemetered data – 1980; Digital format – September 1996; Near-real time processing – 1999	Near real-time video system (2002); direct observation from nearby Klyuchi; satellite imagery.
Klyuchevskoy	Seismic station – 1961; Telemetered data– 1987; Digital format – September 1996; Near-real time processing – 1999	Near real-time video system (2000); direct observation from nearby Klyuchi and Kozyrevsk; satellite imagery.
Bezymianny	Seismic station – 1961; Telemetered data – October 1988; Digital format – September 1996; Near-real time processing – 1999	Near real-time video system (2003); direct observation from nearby Kozyrevsk; satellite imagery.
Plosky Tolbachik	Seismic station – January 1977; Telemetered data – November 1990; Digital format – September 1996; Near-real time processing – 1999	Direct observation from nearby Kozyrevsk; satellite imagery.
Karymsky	Telemetered data – September 1989; Digital format – January 1996; Near-real time processing – 1996	Field observation; satellite imagery.
Koryaksky	Seismic station – April 1963; Telemetered data – 1975; Digital format – January 1996; Near-real time processing – 1996	Direct observation from PK; satellite imagery.
Avachinsky	Seismic station – April 1963; Telemetered data – July 1976; Digital format – January 1996; Near-real time processing – 1997	Direct observation from PK; satellite imagery.
Gorely	Telemetered data – July 1980; Digital format – January 1996; Near-real time processing – 1996	Direct observation from PK; satellite imagery.
Mutnovsky	Telemetered data – July 1980; Digital format – January 1996; Near-real time processing – 1996	Direct observation from PK; satellite imagery.
Alaid	Telemetered data – August 2001; Digital format – August 2001; Near-real time processing – August 2001	Satellite imagery.

KEMSD scientists routinely retrieve and analyze NOAA 16 and 17 images in Petropavlovsk-Kamchatsky through agreement between KEMSD and Federal State Unitary Enterprise “Kamchatkan Center of Communication and Monitoring” that manages a NOAA receiving station in Petropavlovsk. KVERT also receives daily MODIS images from colleagues at the Far East Geological Information Center of the Ministry of Natural Resources in Yuzhno-Sakhalinsk. Although these MODIS images are received as processed .jpg files and cannot be evaluated further for quantitative thermal information, they are useful in delineating some ash cloud features, ash fall deposits, and the presence of thermal anomalies.

In 2005, AVO relayed KVERT information about unrest and color code changes at six Kamchatkan volcanoes and two Kurile volcanoes (tables 4 and 10). For each period of significant, heightened activity, AVO relayed information from KVERT to aviation and weather authorities and hundreds of other recipients through standard notification procedures. As needed, AVO staff communicated directly with KVERT to clarify and verify information and assist users in interpreting data coming from KVERT. Increasingly, routine and low-level volcanic activity email notifications from KVERT and KEMSD staff are being shared directly with aviation and weather authorities around the world. On May 6, 2005, KVERT began distributing its email Information Release statements directly from Kamchatka and AVO no longer relayed these formal announcements by email; however, AVO does continue to rebroadcast the messages through an Internet-based facsimile service and post the messages on the AVO website.

The following summaries refer to events using calendar dates in Kamchatka and Coordinated Universal Time (UTC), which equals ADT + 8 hrs and AST+9 hrs. The equivalent local Kamchatkan time (herein referred to as Kamchatkan Daylight or Standard time) is always 21 hours ahead of Alaska time. This compilation is derived from a number of sources including KVERT weekly updates, unpublished AVO documentation, and Global Volcanism Program Volcanic Activity reports.

Table 10. Russian volcanoes with Color Code changes in 2005.

[Description of Level of Concern Color Codes is shown in table 5]

Color Code	Dates of change
SHEVELUCH	
ORANGE	January 1–February 28
RED	February 28–March 1
ORANGE	March 1–July 8
RED	July 8-9
ORANGE	July 9–September 22
RED	September 22-23
ORANGE	September 23–November 3
YELLOW	November 3–December 31
KLYUCHEVSKOY	
GREEN	January 1-14
YELLOW	January 14-16
ORANGE	January 16–March 24
YELLOW	March 24-28
ORANGE	March 28–April 15
YELLOW	April 15–July 15
ORANGE	July 15-29
YELLOW	July 29–August 12
GREEN	August 12–September 16
YELLOW	September 16–November 3
GREEN	November 3–December 31
BEZYMIANNY	
YELLOW	January 1-7
ORANGE	January 7-11
RED	January 11-12
ORANGE	January 12-14
YELLOW	January 14–November 30
ORANGE	November 30–December 2
YELLOW	December 2-31
KARYMSKY	
ORANGE	January 1–June 10
YELLOW	June 10-23
ORANGE	June 23–December 31
AVACHINSKY	
GREEN	January 1–November 8
YELLOW	November 8–December 23
GREEN	December 23–December 31
MUTNOVSKY	
GREEN	January 1–June 3
YELLOW	June 3-10
GREEN	June 10–December 31
EBEKO	
GREEN	January 1–June 30
YELLOW	June 30–August 12
GREEN	August 12–September 9
YELLOW	September 9–December 31
CHIKURACHKI	
GREEN	January 1–March 13
YELLOW	March 13-25
ORANGE	March 25–April 22
YELLOW	April 22–May 6
GREEN	May 6–December 31

Sheveluch Volcano

CAVW #1000-27

56°38′N 161°21′W
3,283 m (10,768 ft)

Kamchatka Peninsula

LAVA DOME GROWTH CONTINUES
Repeated ash explosions and/or dome collapse and associated pyroclastic flows, ash plumes, gas plumes, ash falls. Sudden, short-lived explosive ash plumes and associated pyroclastic flows on February 27, July 7, and September 22.

Eruptive activity related to growth of the lava dome at Sheveluch continued intermittently through 2005. Seismicity remained above background for nearly the entire year with many weak, shallow earthquakes recorded each day at depths of 0–5 km (0–3 mi) below the volcano and frequent periods of spasmodic volcanic tremor. Two episodes of vigorous dome-building and related explosive activity occurred in 2005.

The volcano began in 2005 at Level of Concern Color Code **ORANGE** with continuation of eruptive activity characteristic throughout 2004 (Girina and others, 2004; Neal and others, 2005b). Seismicity was elevated above background and a thermal anomaly coinciding with the lava dome was seen on many clear AVHRR satellite images of the volcano. A nearly constant fumarolic plume issued from the lava dome and intermittent, sudden explosions from the dome sometimes sent ash to altitudes of more than 20,000 ft (6,100 m) ASL over the course of the year. Pyroclastic flows accompanied some of these explosive episodes. Although many of these events were captured as web camera images or reported by observers in Klyuchi, many explosive events and plumes were inferred on the basis of seismicity according to the empirical model developed by KESMD scientists (Senyukov and others, (2004). KESMD staff in Klyuchi frequently viewed incandescence at the dome, representing new extrusion and hot rock avalanches (fig. 49).

Figure 49. View of Sheveluch Volcano from Klyuchi. Incandescent rockfall path visible on the north flank of the active dome. Other points of incandescence likely are glow from hot gases issuing from the dome. Photograph by Yuri Demyanchuk, IVS, February 2, 2005.

A sudden explosion on February 27 sent ash to about 28,000 ft (8,500 m) ASL where it drifted to the southwest and west. Ash fall occurred at Klyuchi mixed with snow in a layer 2–3 cm (0.8–1.2 in.) thick. A significant pyroclastic flow with a run out of 25 km (15.5 mi) accompanied this explosion, resulting in a very large thermal anomaly southwest of the dome in the area of the long-term pyroclastic fan (fig. 50). Satellite data indicated an ash plume extending up to 700 km (435 mi) from the volcano.

KVERT raised the volcano to Level of Concern Color Code **RED** for several days. The single seismic station (SVL) on the volcano was destroyed by this eruption. Over subsequent weeks, dome growth continued based on the continuing thermal anomaly, avalanches off the dome accompanied by small ash clouds, and visual observations of extrusive lobes on the dome.

Dome growth continued steadily until an 11-minute-long event on July 7 sent ash above 23,000 ft (~7,000 m) based on visual observations near the volcano; seismic estimates of the eruption plume put it above 30,000 ft (9,100 m). For this explosion, KVERT briefly raised the Level of Concern Color Code to **RED**. Weak ash plumes and fumarolic plumes extended tens of km downwind intermittently. A persistent thermal anomaly and fumarolic plume, occasionally containing minor amounts of ash, were recorded. Hot avalanches and rockfalls continued intermittently (fig. 51). Visual observations during daylight hours also confirmed extrusion of new lava flows on the dome (fig. 52).

On September 22, another sudden and violent explosion from the dome sent ash above 24,000 ft (7,300 m), and produced ash fall on the southwest flank of the volcano. Vigorous activity lasted for about 21 hours according to seismicity. KVERT raised the Level of Concern Color Code again to **RED** for less than 24 hours, then reverted to **ORANGE** as seismicity stabilized and no further violent ash emissions occurred. The September 22 event produced pyroclastic flows that traveled as far as 20 km (~12 mi), and a light, brown ash fall at Klyuchi (fig. 53).

Seismicity at Sheveluch declined in October although weak fumarolic activity, reports of incandescence, and occasional avalanches and rock fall continued. KESMD installed three new seismic stations in late October, and on November 3, KVERT lowered the Level of Concern Color Code to **YELLOW**. Dome growth continued through the end of the year accompanied by low levels of seismicity, a persistent fumarolic plume and thermal anomaly, and occasional glow from the dome area.

Sheveluch Volcano is one of the largest and most active volcanoes in Kamchatka with at least 60 large eruptions during the Holocene (Bogoyavlenskaya and others, 1985; Ponomareva and others, 1998). The northernmost active volcano on the Peninsula, historical eruptive activity has been characterized by lava dome growth and explosive collapse. In 1964, Sheveluch produced a massive flank collapse, debris avalanche, and lateral blast. The current protracted, episodic phase of lava dome growth began in August 1980 and continues into 2006.

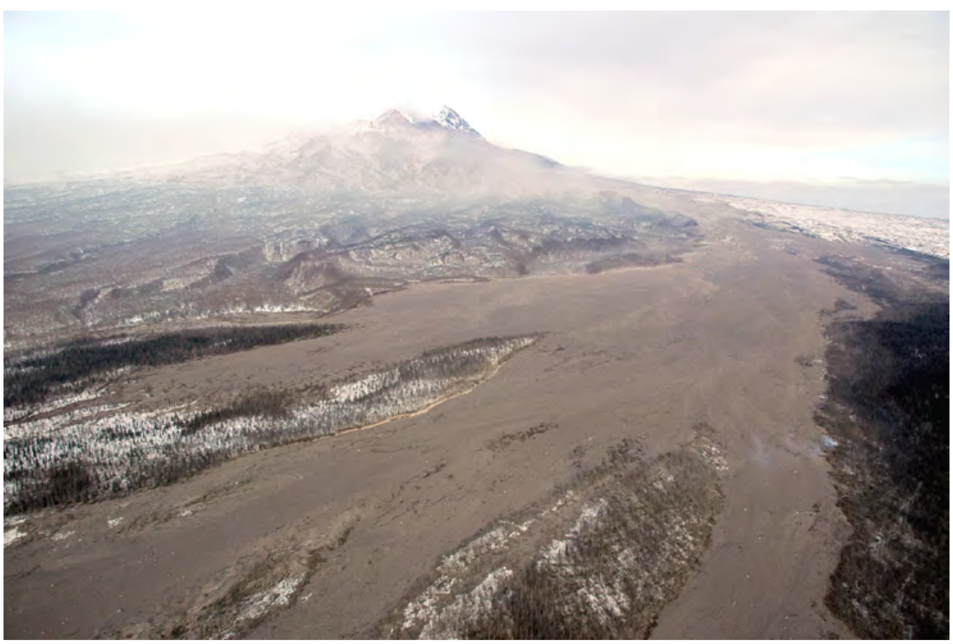


Figure 50. Pyroclastic flow deposits from the February 27, 2005, explosive eruption of Sheveluch Volcano. Photograph by Yuri Demyanchuk, IVS, March 18, 2005.

Figure 51. Rock avalanche in progress off the north flank of the active lava dome at Sheveluch Volcano. Photograph by Natasha Gorbach, IVS, June 30, 2005.

Figure 52. Active lava dome at Sheveluch Volcano. Dark mound is recent lava dome extruded from February 28, 2005. Photograph by Natasha Gorbach, IVS, June 30, 2005.

Figure 53. Ash fall from September 22 eruptive event at Sheveluch. Ash extended at least 20 km (12 mi) SSW from the dome and was 20–30-mm (0.8–1.2-in.) thick at this camp, 9 km (5.6 mi) SW of the dome. Photograph by V. Kozlov, KEMSD, date unknown.

Klyuchevskoy Volcano

CAVW #1000-26

56°03′N 160°38′W
4,750 m (15,589 ft)

Kamchatka Peninsula

STROMBOLIAN ERUPTION; LAVA FLOWS; LAHARS from late January into early April.

Klyuchevskoy Volcano resumed vigorous Strombolian eruptive activity in 2005. Based on increasing seismicity, KVERT declared Color Code **YELLOW** on January 14 and then **ORANGE** on January 16 as seismicity accelerated and a prominent thermal anomaly appeared in the summit area on AVHRR satellite images.

On January 22, steam explosions occurred in the summit crater and Strombolian activity sent incandescent bombs as far as 300 m (~1,000 ft) above the crater rim (fig. 54). Light ash fall was reported in Klyuchi on January 31. A lahar on the same day traveled to within 6 km (3.7 mi) of Klyuchi. KVERT proposed that a lava flow may have formed on the ice-covered upper flank of the volcano producing the lahar. An overflight of the volcano on February 16 revealed a cinder cone growing inside the summit crater; the web camera showed an incandescent lava flow moving down the steep northwest flank in the Krestovsky channel (fig. 55). In daylight, phreatic explosions and steaming occurred at the margins of the flow as it interacted with snow and ice on the cone on February 6 (figs. 56 and 57). Seismicity remained very high and ash fall was observed on the flank of Ushkovsky Volcano about 10 km (6 mi) in the distance.

Figure 54. Strombolian activity at Klyuchevskoy Volcano reflected in the eruptive plume on January 22, 2005. Photograph by Yuri Demyanchuk, IVS.

Figure 55. Web camera image of Klyuchevskoy Volcano on February 7, 2005. Strombolian activity in the summit crater feeds a lava flow moving down the northeast flank of the cone. Image courtesy of KEMSD.

Figure 56. Klyuchevskoy Volcano with summit plume from Strombolian eruptive activity. Flank plume is produced by the explosive interaction of lava and snow and ice high on the cone. Image courtesy of Yuri Demyanchuk, IVS, February 6, 2005.

Figure 57. Lava flow in Krestovsky Channel on the northwest flank of Klyuchevskoy Volcano. Image courtesy Yuri Demyanchuk, IVS, February 16, 2005.

Vigorous Strombolian eruption continued accompanied by ash and gas plumes, and at times ash-rich plumes above 26,000 ft (~7,900 m). The growing lava flow and related flowage deposits resulted in a large thermal anomaly visible on many AVHRR and other satellite images (fig. 58). Ash falls occurred at nearby villages, including the community of Kozyrevsk (fig. 48).

By mid-March, two separate lobes of lava were traveling down the northwest flank of the volcano. The intensity of activity increased in late March and on the 24th KVERT declared Color Code **RED**. Ash was lofted as high as 28,500 ft (~8,700 m) ASL and ash fall occurred over a period of many hours at Klyuchi. On March 24, the eruptive plume extended as far as 560 km (~350 mi) downwind. Pilots reported ash rising to 22,100 ft (~6,700 m) and drifting to the north on March 31.

On March 28, seismicity and the level of activity decreased and KVERT reverted to **ORANGE**. Strong incandescence persisted, however, and ash was reported above 25,000 ft (~7,600 m). By April 15, activity had significantly decreased and KVERT established Color Code **YELLOW**. Seismicity remained above background and a gas plume accompanied at times by light ash extended above the summit crater. On July 14, activity intensified and KVERT upgraded the volcano to **ORANGE** for several weeks. During this time, seismicity and tremor were elevated above background and a steam and gas plume emerged from the summit crater. No renewed eruptive activity ensued and the volcano was downgraded to **YELLOW** and then **GREEN** on July 28 and August 12, respectively. On September 16, an increase in tremor amplitude prompted a Color Code **YELLOW** declaration that remained in effect until November 3, when the Color Code for the volcano was lowered to **GREEN** where it remained through the year's end.

Klyuchevskoy is a classic, symmetrical stratovolcano and, at 4,750 m (15,580 ft), it is the highest of the active European and Asian volcanoes. Klyuchevskoy frequently is active with Vulcanian to Strombolian explosions and occasional lava-flow production from the main vent in the steep-walled summit crater or from flank vents (Khrenov and others, 1991). Explosive eruptions are recorded in nearly every decade and at multiple times during most years since the early 1700s (Simkin and Siebert, 1994). Klyuchevskoy's most recent significant ash-producing eruption that significantly impacted air traffic in the North Pacific was September 30–October 1, 1994 (Ozerov and others, 1996).

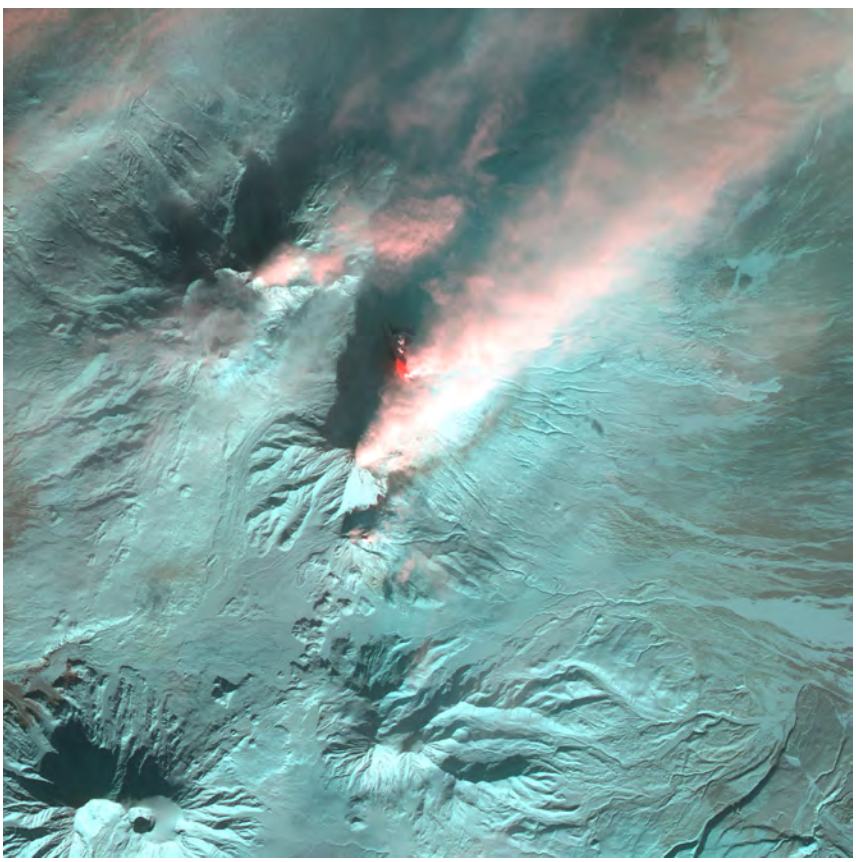


Figure 58. ASTER image of Klyuchevskoy Group of volcanoes in Kamchatka. Red area shows the zone of higher temperatures related to active lava flow production at Klyuchevskoy. Image taken on February 24, 2005. Courtesy of NASA.

Bezymianny Volcano

CAVW #1000-25

55°58′N 160°36′W
2,800 m (9,187 ft)

Kamchatka Peninsula, Russia
CONTINUED LAVA DOME GROWTH with two brief explosive episodes

Bezymianny Volcano continued slow, relatively quiet lava dome growth through 2005 punctuated by two episodes of explosivity that prompted KVERT to raise alert levels. After beginning the year at Code Color YELLOW, increasing seismicity and the appearance of a thermal anomaly in the summit dome region led to a Color Code ORANGE declaration on January 6. On January 11, an explosive event began at 08:02 UTC and based on the amplitude of seismicity, KEMSD estimated that ash had reached as high as 26,000–33,000 ft (~8,000–10,000 m) ASL. The strong seismicity lasted until 08:45. Visual confirmation and satellite analysis was hampered by a storm system in the region. On January 11, satellite data indicated an ash cloud 50 km (31 mi) in diameter and extending 160 km (100 mi) to the southwest of the volcano. Ash deposits were visible on the snow (fig. 59). KVERT inferred that lava extrusion occurred following this explosion.

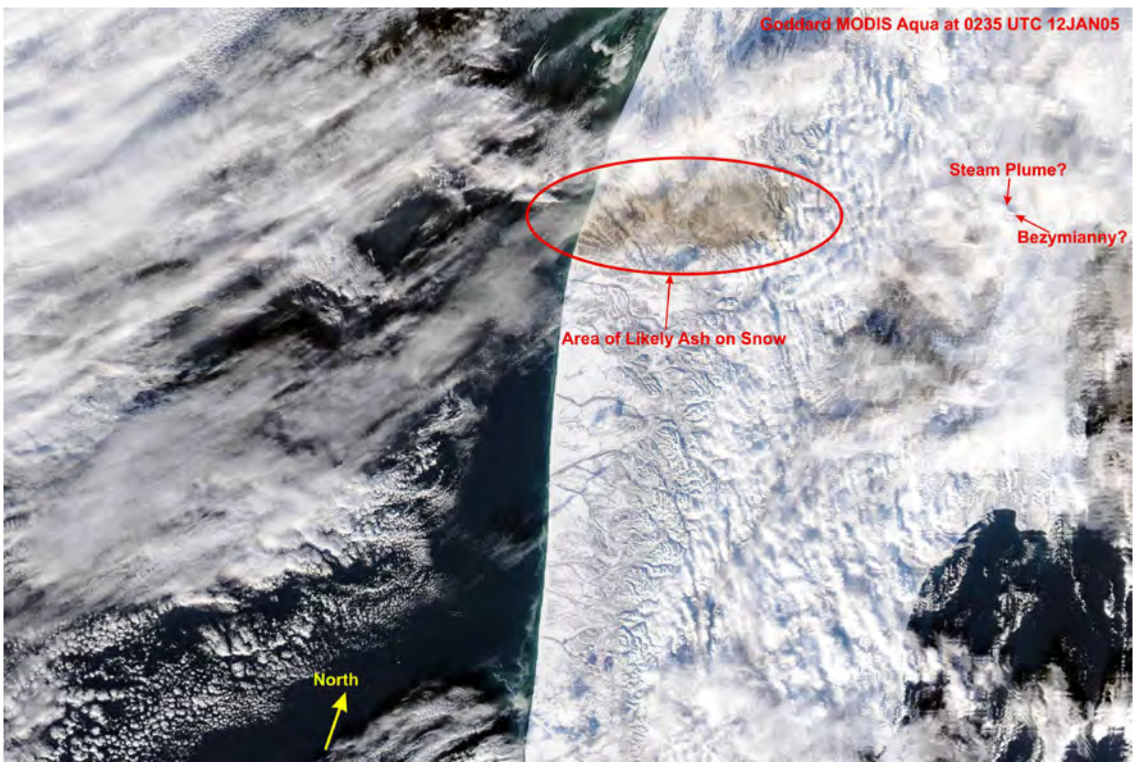


Figure 59. MODIS image of the western Kamchatka Peninsula coastline. Area of ash fall from Bezymianny Volcano is circled. Image date January 12, 2005, at 0235 UTC. Courtesy NASA; image annotated by Steve Smith.

Seismicity declined markedly following this event and on January 14, KVERT reverted to Level of Concern Color Code YELLOW. For the next several months, strong volcanic tremor at nearby Klyuchevskoy Volcano interfered with analysis of the seismic data from Bezymianny's single station. The persistent gas plume (fig. 60) and satellite-detected thermal anomaly at the dome, however, suggested continued effusion. In late July, a helicopter overflight of the volcano revealed a new central crater and a crack on the SE slope of the active dome. Observers noted occasional avalanches of hot rock from the steep-sided dome. The waning eruption at Klyuchevskoy allowed small earthquakes to be detected again at Bezymianny beginning in mid-summer, however overall seismicity was low.

On November 25, KVERT reported shallow earthquakes at the volcano and a continuing increase in the strength of the thermal anomaly that began on November 16. Based on this, they indicated that the likelihood of an explosive event had increased. On November 29, KVERT elevated the Level of Concern Color Code to **ORANGE**. An increasing number of small, hot avalanches from the dome were observed and the web camera showed the onset of strong fumarolic degassing on November 29. On November 30, a protracted explosive event occurred from about 12:00–13:15 UTC. Due to a severe storm at that time, there were no observations of activity; however, satellite data indicated a plume extending southwest from the volcano at an estimated height of 20,000 ft (6,000 m). Activity decreased quickly in intensity and on December 1, KVERT reverted to Color Code **YELLOW**. Slow, fairly quiet lava extrusion continued into 2006.

In October 1955, Bezymianny Volcano emerged from a 900–1,000 year period of quiescence commencing an explosive eruption that culminated on March 30, 1956, with the catastrophic failure of the eastern flank and debris avalanche and lateral blast. Since then, lava extrusion has produced a dome that periodically collapses, generating pyroclastic flows and short-lived ash plumes (Girina and others, 1993).

Figure 60. Active lava dome at Bezymianny Volcano. A plume of water vapor and other volcanic gas is visible over the summit of the dome. Photograph courtesy Yuri Demyanchuk, IVS, February 16, 2005.

Karymsky Volcano

CAVW #1000-13

54°03′N 59°27′W
1,486 m (4,876 ft)

Kamchatka Peninsula, Russia

STROMBOLIAN / VULCANIAN ERUPTION CONTINUES.

Intermittent, low-level Vulcanian and Strombolian eruptions, explosions, localized ash fall, lava extrusion, rock avalanches, degassing.

Karymsky Volcano began 2005 at Level of Concern Color Code **ORANGE** and continued its relatively high level of activity into a tenth year.

Satellite monitoring of the volcano indicated a persistent thermal anomaly in the vicinity of the summit crater; frequently on clear images, a swath of new ash radiating sometimes tens of kilometers away from the cone was visible on the landscape. Seismic data flow was interrupted for much of the first part of the year; however, when operating it was typical to detect more than 100 and sometimes several hundred shallow earthquakes and numerous avalanche signals per day at Karymsky. A steam and gas plume nearly always was present above the volcano; at times of vigorous explosive activity, this plume contained visible ash and extended as high as 8,000–16,000 ft (~2,500–4,900 m) ASL and downwind for tens of kilometers. In April, Strombolian activity was visible at night above the summit crater and field crews observed pyroclastic avalanches down the steep flanks of the cone.

In early June, decreased seismicity prompted a downgrade to Level of Concern Color Code **YELLOW** on June 10; however, seismicity increased again and Color Code **ORANGE** was declared on June 23. In the following months, explosive activity occurred more frequently than earlier in the year, sending ash above 10,000 ft (~3,000 m). Many of these plumes were inferred based on seismicity. In early September, ash plumes reached 19,000 ft (~5,800 m) ASL and extended 30 km (~19 mi) downwind. By October, field observers noted new lava inside the summit crater, nearly filling the feature (fig. 61). Explosions destroyed portions of this new lava dome inside the summit crater.

Seismic data became intermittent due to technical problems in early November; however, lava effusion continued along with occasional ash clouds. In late December, a new pyroclastic cone 60–80 m (~200–260 ft) in diameter was spotted in the summit crater; the new cone contained a small lava dome within its own crater.

Figure 61. Oblique aerial view of Karymsky Volcano on September 25, 2005. Steam and volcanic gas rises above a viscous lava flow that partially fills the active crater. Photograph courtesy Michael Zelenski, IVS.

The current, protracted eruption began in mid-April 1995 with increasing seismicity that led up to an explosive eruption that began on January 1, 1996, simultaneously at Karymsky Volcano and from a vent at the north part of Karymsky Lake about 10 km (6 mi) in the distance (Fedotov, 1998; Belousov and Belousova, 2001). For the next several years, periods of explosive eruptions of ash and small blocks alternated with periods of lava flow production (Neal and McGimsey, 1997; McGimsey and Wallace, 1999; see subsequent annual reports, table 7). Karymsky usually issues a continuous steam plume and is the most active volcano on the Kamchatkan Peninsula (Simkin and Siebert, 1994). Explosive and effusive-explosive eruptions of andesitic tephra and lava flows alternating with periods of repose are typical of Karymsky (Ivanov and others, 1991).

Avachinsky Volcano

CAVW #1000-10

53°15′N 158°51′W
2,751 m (8,890 ft)

Kamchatka Peninsula, Russia
INCREASED SEISMICITY AND THERMAL SIGNATURE. No eruption ensued.

In early November, KEMSD scientists noted that the rate of occurrence of shallow earthquakes below Avachinsky Volcano had increased over the past month. A weak thermal anomaly was detected in satellite images and, based on this departure from typical patterns, KVERT declared Level of Concern Color Code **YELLOW** on November 8. Seismicity continued to increase over the next several weeks and included shallow, high frequency and hybrid event types. The thermal anomaly persisted and moderate fumarolic emissions occurred from the summit area until early December. No further acceleration of activity occurred, and by December 23, the thermal anomaly had been absent for several weeks and seismicity had declined. KVERT returned to Level of Concern Color Code **GREEN**.

Avachinsky Volcano is the volcano nearest Petropavlovsk-Kamchatsky, the largest city in Kamchatka (population about 200,000 and the home of KVERT and its constituent Russian Institutions). The snow-clad volcano looms only 25 km (15 mi) north of the city (fig. 48) and frequently emits a white steam plume above its summit. Its last eruption was in 1991 and consisted of several explosions that dusted Petropavlovsk-Kamchatsky with several millimeters of ash, followed by a period of lava flow production and further explosions. Fumarolic activity in the summit area reflects magmatic degassing; temperatures as high as 473°C (883°F) were measured in 1993–94 (Taran and others, 1997). In October 2001, a phreatic explosion accompanied by a temporary increase in seismicity occurred (fig. 62; McGimsey and others, 2004b; table 7). Avachinsky and its neighbor Koryaksky are monitored by a network of five short-period seismic stations.

Figure 62. Summit of Avachinsky Volcano on September 8, 2002. The summit crater is filled by lava from the 1991 eruption. Photograph courtesy of N. Seliverstov, IVS. The Pacific Ocean is visible in the distance.

Mutnovsky Volcano

CAVW #1000-06

52°27′N 158°12′W
2,323 m (7,621 ft)

Kamchatka Peninsula, Russia
INCREASED FUMAROLIC ACTIVITY. No eruption ensued.

Unrest at Mutnovsky Volcano was suggested by the appearance of a weak thermal anomaly in satellite imagery in late May. A geothermally active volcanic center, ground observers noted unusually hot local gas emission around this same time. KVERT raised the Level of Concern Color Code to **YELLOW** on June 3. On June 10, after 1 week of no significant change, KVERT returned to **GREEN**. No further unrest ensued.

Mutnovsky Volcano is considered to be one of the most active volcanoes of southern Kamchatka (figs. 48 and 63). It is composed of four overlapping stratovolcanoes, the youngest of which is early Holocene in age. Simkin and Siebert (1994) record 11 eruptions in the 20th century, most of which were small, phreatic explosions except for a lava-flow-producing event in 1904. Phreatic explosions occurred at Mutnovsky most recently in 2000 (table 7). Commercial development of the volcano for geothermal power is underway.

Figure 63. Mutnovsky Volcano, viewed from the west. Photograph courtesy of M. Zelenski, IVS.

Ebeko Volcano

CAVW #0900-38

50°41′N 156°01′W
1,156 m (3,793 ft)

Paramushir Island, Northern Kuriles
INCREASED FUMAROLIC ACTIVITY AND PHREATIC EXPLOSIONS

Increased fumarolic activity at Ebeko Volcano on Paramushir Island prompted KVERT to raise the Level of Concern Color Code to **YELLOW** on January 30. KVERT observers on the island noted a strong smell of hydrogen sulfide and a yellow-gray fumarolic plume from the summit of the volcano. A new turquoise-colored lake had appeared in the summit area and several millimeters of ash fall was noted 500 m east of the main summit crater. Only 1 day later, the new lake had disappeared and multiple fumarolic vents were active in the basin. Several local earthquakes, possibly related to this activity, were recorded on a single seismic station in Severo–Kurilsk, 9 km (5.6 mi) from the volcano.

On February 8, a fumarolic plume containing minor amounts of ash rose to about 7,000 ft (~2,150 m) ASL and observers reported an ash fall at Severo–-Kurilsk. Over the next week, the fumarolic plume contained dark gray ash, and light ash fell near the volcano. Hydrogen sulfide odor was strong in Severo–Kurilsk; this occurred several times during this episode of increased fumarolic output. In the vicinity of the volcano on February 25 observers reported a strong chlorine odor.

Poor weather prevented any direct observation of the volcano until March; however, by late March activity was deemed to have diminished in intensity and KVERT returned Ebeko to Color Code **GREEN**.

Observation of a new explosion crater emitting hot steam prompted another Color Code **YELLOW** declaration on July 29; however, less than 2 weeks later, KVERT returned to **GREEN**, then back to **YELLOW** on September 9 when field observers again noted increased fumarolic activity. High temperatures were measured in the summit fumarole field (470°C [878°F]). Activity continued at about this level through the end of the year.

Ebeko Volcano on Paramushir Island (fig. 64) is one of the most active of Kurile Island volcanoes. Summit craters are aligned SSW-NNE and the volcano actually is the northernmost of a cluster of five volcanic cones. Strong, sulfurous geothermal activity is common at Ebeko. Historical eruptions have consisted largely of explosive and predominantly phreatic eruptions from the summit craters (Simkin and Siebert, 1994).

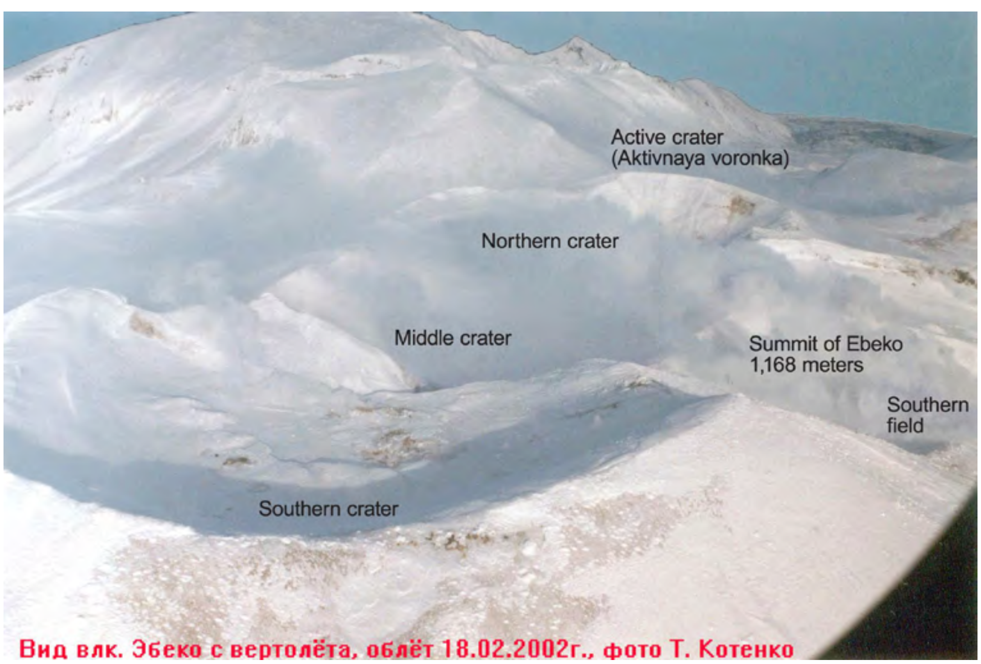


Figure 64. Oblique aerial view of active summit craters of Ebeko Volcano. Note vapor plume filling the middle and northern craters. North is approximately towards the top of this image. Photograph by Tatiana Kotenko, KVERT, February 18, 2002.

Chikurachki Volcano

CAVW #0900-36

50°19′N 155°28′W
1,816 m (5,958 ft)

Paramushir Island, Northern Kuriles

BRIEF, MILD EXPLOSIVE ASH PRODUCTION IN MARCH AND APRIL

A gas and steam plume emanating from Chikurachki Volcano was discovered in satellite imagery of the northern Kuriles between March 11–16 (fig. 65). Detection of ash in a plume on March 25 prompted KVERT to declare Level of Concern Color Code **ORANGE** for the volcano. Subsequent satellite images showed ash fall on the southern part of Paramushir Island extending as far as 20 km (~12 mi) southeast of the volcano. On April 7, analysis of satellite data suggested ash from the volcano reached 33,000 ft (10,000 m) ASL.

KVERT downgraded the volcano to Code Color **YELLOW** on April 22 after several weeks of weak fumarolic activity with no ash production. **GREEN** was declared on May 6.

Chikurachki is the highest volcano on Paramushir Island in the northern Kuriles. Direct information about the volcano is limited and intermittent because it is not monitored seismically, and few people live nearby. Situated 105 km (65 mi) southwest of the tip of the Kamchatkan Peninsula, the volcanic cone of Chikurachki is distinctively red due to the abundance of oxidized basaltic andesite scoria on its upper flanks (Gorshkov, 1970, fig. 19; Simkin and Siebert, 1994). There are at least six known historical eruptions attributed to Chikurachki, including its largest historical eruption of about 1 km^3 (0.24 mi^3) of material in 1853. Its most recent eruption was in 2003 (McGimsey and others, 2005b; table 7).

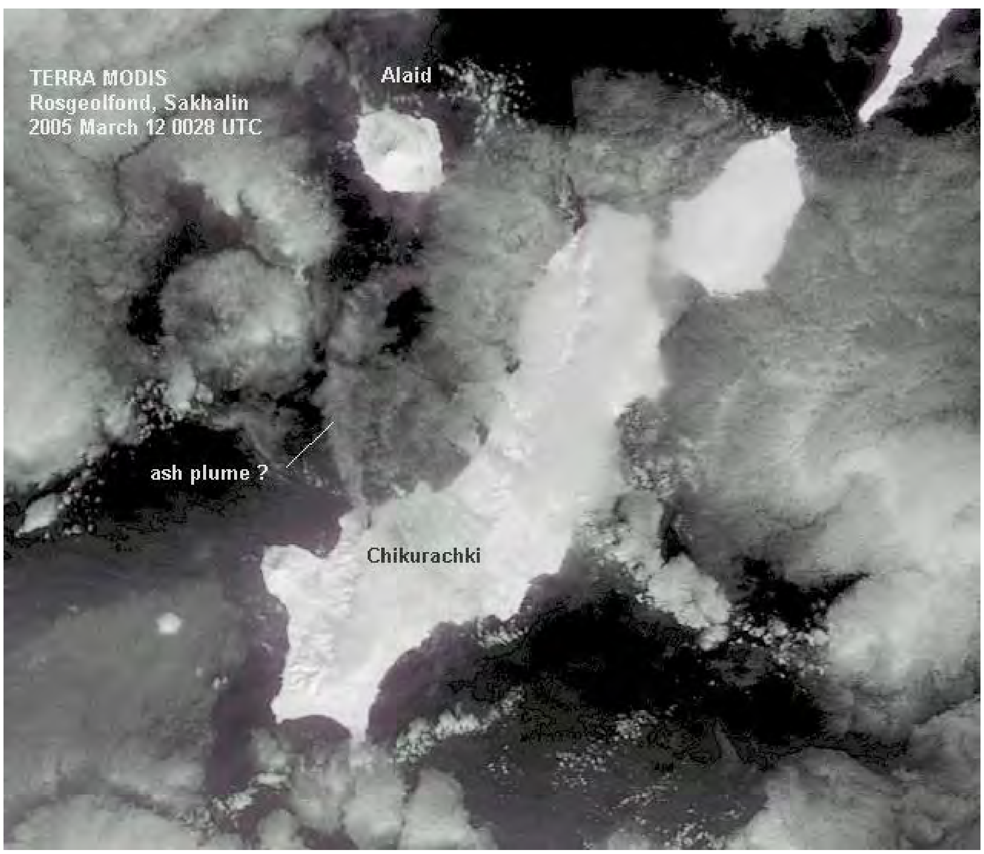


Figure 65. MODIS image of Paramushir and Atlasova Islands in the northern Kuriles on March 12, 2005 (00:28 UTC). A plume likely containing ash is drifting north about 40 km (25 mi) from Chikurachki Volcano. The southern tip of the Kamchatka Peninsula is visible in the upper right. Image courtesy of NASA and Rosgeolfond, Sakhalin.

Acknowledgments

We thank Bill Burton (USGS) and Cheryl Cameron (AKDGGS) for their thoughtful, careful reviews. Working as a volunteer, Annie Douglas compiled much of table 7, which presents cross-referenced lists of the contents of previous years' summary reports.

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Summary

This report summarizes volcanic activity in Alaska, Kamchatka, and the Kurile Islands in 2005 and describes AVO's operational response. Volcanic activity, or suspected activity occurred at or near 16 volcanoes in Alaska, and 8 volcanoes in Russia. Volcanic activity in Alaska occurred at Mount Spurr (all 2005), Augustine (May-December), Chiginagak (November 2004 to May 2005), Veniaminof (all 2005), Cleveland (August and October), and Korovin (February). Suspected activity was reported at Iliamna, Katmai Group, Aniakchak, Pavlof and Mount Hague, Shishaldin, Cleveland, Kasatochi, and Tanaga. In 2005 AVO issued daily Status Reports on Alaska volcanoes, 53 Weekly Updates, and 20 Information Releases. Eight Russian volcanoes were active: Sheveluch, Klyuchevskoy, Bezymianny, Karymsky, Avachinsky, Munovsky, Ebeko, and Chikurachki. AVO distributed 71 KVERT Information Releases.

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Glossary of Selected Terms and Acronyms

AAWU: "Alaska Aviation Weather Unit" of the National Weather Service.

a'a: Hawaiian term for lava flows characterized by a rough, jagged, blocky surface, typically difficult to walk upon.

ADT: "Alaska Daylight Time", UTC-8 hours ADT.

AEIC: "Alaska Earthquake Information Center".

ADDGS: "Alaska Division of Geophysical & Geological Surveys".

ASL: "above sea level".

AST: "Alaska Standard Time", UTC-9 hours AST.

ASTER: "Advanced Spaceborne Thermal Emission and Reflection Radiometer"

AVO: "Alaska Volcano Observatory".

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

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

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

basalt: general term for dark-colored igneous rock, usually extrusive, containing about 45 to 52 weight percent silica (SiO2, 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".

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

COSPEC: "Correlation Spectrometer"; device for measuring sulfur dioxide emissions.

CWSU: "Center Weather Service Unit" of the National Oceanic and Atmospheric Administration, stationed at the Air Route Traffic Control Center.

FAA: "Federal Aviation Administration".

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

fault: a fracture or zone of fractures along which there has been displacement of the sides relative to one another.

FIR: "Flight Information Region".

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

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

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

GINA: Geographic Information Network of Alaska.

GIS: geographic information system.

glaciolacustrine: pertaining to sediments deposited in glacial lakes, and resulting landforms.

GMS: "Geostationary Meteorological Satellite".

GOES: "Geostationary Operational Environmental Satellite".

graben: an elongate, relatively depressed crustal block that is bounded by faults on its long sides.

GPS: Global Positioning System.

GVN: "Global Volcanism Network" of the Smithsonian Institution.

HST: "Hawaii-Aleutian Standard Time", equals UTC-10 hours HST.

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

incandescent: glowing red or orange due to high temperature.

intracaldera: refers to something within the caldera.

IKONOS: a commercial earth observation satellite; imagery has been available since January 1, 2000; "IKONOS" is from the Greek word for "image".

IMGG: Russian "Institute of Marine Geology and Geophysics".

IVGG: Russian "Institute of Volcanic Geology and Geochemistry".

IVS: Russian "Institute of Volcanology and Seismology".

JMA: "Japanese Meteorological Agency".

JPEG: "Joint Photographic Experts Group"; type of digital photographic file.

Ka: Thousands of years before the present.

KDT: "Kamchatkan Daylight Time", equals ADT + 21 hrs.

KEMSD: Russian "Kamchatka Experimental and Methodical Seismology Department".

KST: "Kamchatka Standard Time", equals AST + 21 hrs.

KVERT: "Kamchatkan Volcanic Eruption Response Team".

Landsat: NASA satellite(s) that have collected images of earth's surface for over 35 years.

lapilli: pyroclasts that are between 2 and 64 mm in diameter.

lava: molten material that reaches the earth's surface.

magma: molten material below the surface of the earth.

MODIS: Satellite-based"Moderate-Resolution Imaging Spectroradiometer".

MWO: "Meteorological Watch Office".

NOAA: "National Oceanic and Atmospheric Administration".

NOPAC: "North Pacific Air Corridor".

NOTAM: "Notice to Airmen", a notice containing information [not known sufficiently in advance to publicize by other means] concerning the establishment, condition, or change in any component [facility, service, or procedure of, or hazard in the National Airspace System] the timely knowledge of which is essential to personnel concerned with flight operations.

NPS: "National Park Service".

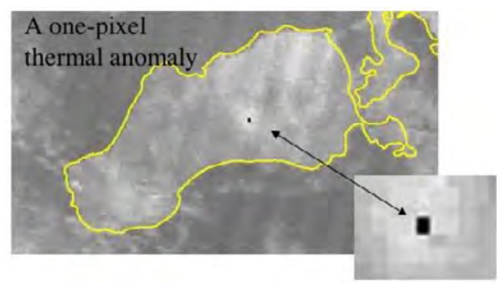
NWS: "National Weather Service".

phreatic activity: an explosive eruption caused by the sudden heating of ground water as it comes in contact with hot volcanic rock or magma.

phreatic ash: fine fragments of volcanic rock expelled during phreatic activity; this ash is usually 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.



PK: "Petropavlovsk"; capital city of Kamchatka, Russia.

Pleistocene: geologic epoch extending from 2-3 million years ago to approximately 10,000 years before present

PUFF: a volcanic ash tracking model (see: http://pafc.arh.noaa.gov/puff/index.html).

pumice-rich lapilli: particles ejected during a volcanic eruption that are composed mostly of pumice and between 2 and 64 mm in size.

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

QuickBird: a high-resolution commercial earth observation satellite, launched in 2001 as the first satellite in a constellation of three scheduled to be in orbit by 2008. QuickBird collects the highest resolution commercial imagery of Earth.

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

RFE: "Russian Far East".

SAB: "Synoptic Analysis Branch" of NOAA.

SAR: "Synthetic Aperture Radar".

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

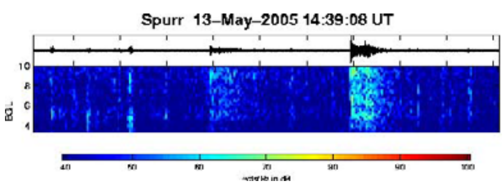
seismic swarm: a flurry of closely spaced earthquakes or other ground shaking activity; often precedes an eruption.

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

SIGMET: "Significant Meteorological information statement", issued by NWS.

SVL: single seismic station.

spectrogram: a graphic depiction of seismic amplitude in different frequency bands.



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.

sub-plinian: style of explosive eruptions characterized by vertical eruption columns and widespread dispersal of tephra.

SVA: "suspect volcanic activity".

SVERT: "Sakhalin Volcanic Eruption Response Team" monitoring and reporting on Kurile Island volcanoes.

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

t/d: tonnes per day; applies to gas emission rates for CO_2, SO_2, and H_2S.

TFR: "Temporary Flight Restriction", issued by FAA.

UAFGI: "University of Alaska Fairbanks Geophysical Institute".

USCG: "United States Coast Guard".

USGS: "United States Geological Survey".

USFWS: U.S. Fish and Wildlife Service.

UUA: "Urgent pilot report".

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

VAAC: "Volcanic Ash Advisory Center".

VAAS: "Volcanic Ash Advisory Statement".

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

VNIR: "Visible Near Infrared" satellite image; healthy vegetation appears red.

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

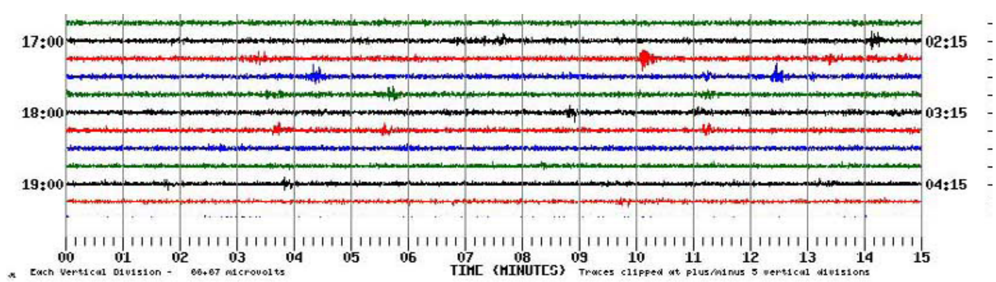
Vulcanian: style of explosive eruption consisting of repeated, violent ejection of incandescent fragments of viscous lava, usually in the form of blocks, along with volcanic ash. Sometimes, Vulcanian eruptions involve water mixing with erupting magma.

UAFGI: "University of Alaska Fairbanks Geophysical Institute".

VTTS: Valley of Ten Thousand Smokes.

webicorder: computer simulation of a drum seismograph, based on digital seismic data, posted to AVO's public website.

webicorder



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