Alaska Volcano Observatory

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September through December 1999

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Cover photos: left, north flank of Shishaldin volcano covered with ash and debris flows following the recent eruption. Photo taken August 8, 1999; rght, Shishaldin in eruption, April, 1999. Photos taken by G. McGimsey.

In This Issue

Highlights

- Our Scientist-in-Charge for 61/2 years, Terry Keith, departs for California.
- Minor unrest continues at Shishaldin.
- An M=7.0 earthquake under Kodiak Island triggered seismicity at Katmai, 100km away.
- Much of the new Kanaga net failed shortly after installation, but the net at Great Sitkin is functioning well.
- The second stage of construction of the Experimental Petrology Laboratory at UAF was completed.

Summary

Human events overshadowed volcanic ones during this report period, as Terry Keith completed her term as Scientist-in-Charge of AVO. As Terry documents herein in her closing report, this was a chapter of great growth and challenge in AVO's development. We look forward to working with her in her new role as Chief Scientist of the USGS Volcano Hazards Program.

John C. Eichelberger

A Farewell to Alaska

Reflection on 6 1/2 years as AVO SIC - April 1993 through September 1999

I haven't had much time to reflect on my 6 1/2 years as AVO SIC from April 1993 through September 1999 but a lot of great things happened during that time and it was mainly due to the hard work and efforts of the folks who make up AVO. Being SIC of AVO was a really good job, though stressful in many ways. Tom Miller was a hard act to follow as were the closely spaced Cook Inlet eruptions of Augustine 1996, Redoubt 1989-90, and Spurr 1992. So one of my first decisions for AVO was whether to stay simply the "Cook Inlet Volcano Observatory" and wait around for the next eruption (which hasn't happened yet) or to stretch and truly become the Alaska Volcano Observatory. You know what we did because many of you stretched yourselves with your time and efforts to make the Alaska Volcano Observatory not only span the 2800km of the Aleutian arc with its 40 historically active volcanoes but also to monitor the 30 active volcanoes in Kamchatka, Russia.

I started thinking in detail about all that happened during those years-the eruptions, growth in scientific disciplines and

continued

expansion of volcano hazard monitoring capabilities, but it's way too long so I'll try to make this concise.

AVO expanded from seismically monitoring four volcanoes in real-time to instrumenting 20 volcanoes for real-time seismic monitoring. How many folks really comprehend what this has meant in terms of added workload both in the field and in the lab?! In order to really get into the Aleutian monitoring game, we had to develop satellite remote sensing techniques to monitor over 70 historically active volcanoes and their drifting ash clouds in near real time across the North Pacific region. In essence AVO now monitors the entire North Pacific region on a 24-hr basis. This is truly remarkable for our relatively small staff.

We developed working relationships with other Federal and State agencies in Alaska and on the national level (including NOAA, FAA, USAF, Alaska Division of Emergency Services) to build a communications infrastructure that could give warnings of volcano hazards to the air carrier industry and the public on the order of minutes. Elements of our infrastructure, including our Level of Concern Color Code, were used in developing a draft National Plan for volcanic hazards notifications and aircraft safety, and for NOAA to develop their Volcanic Ash Advisory Center's (VAAC) in conjunction with local volcano observatories if available at an international level.

In 1996, AVO was awarded Vice-President Gore's Hammer Award (my personal "Sword of Damocles") for making government more efficient. The Hammer certainly provided some entertainment such as John Eichelberger and I not being able to carry it back and forth between Anchorage and Fairbanks on airplanes because it was a "weapon". Yes, indeed. Then John leaving it in the Anchorage airport checked baggage so I had to go rescue it. Then it mercifully disappeared and became a virtual Hammer Award!

Looking at some figures put together for AVO from 1988-July 1999, AVO dealt with at least one period of activity (eruption, significantly increased fumarolic activity, or seismically detected intrusion) at each of 20 Alaskan volcanoes and multiple significant events disrupting air traffic at each of 7 Kamchatkan volcanoes. We spent 27 days in Level of Concern Color Code Red, 136 days in Orange, 760 days in Yellow, and 49 days in Green associated with crisis response for Alaskan volcanoes. For Kamchatkan volcanoes from January 1998-August 1999 alone we supported KVERT for 10 days in Orange and 507 days in Yellow (I didn't get a count on previous KVERT statistics). For the Alaskan volcanoes, this adds up to 972 days or 2.66 yrs on 24-hr duty (including on-call)! No wonder we got tired!

Much was learned about the variety of Aleutian volcanoes, their varied eruption styles, and how to apply monitoring techniques effectively to remote regions. We did a lot of research in both science and technology.

We produced journal research papers, represented AVO well at AGU, SSA, GSA, and foreign meetings, began a new series of Volcano Hazards Assessments for Alaskan volcanoes, published a few geologic maps of Alaskan volcanoes,

I hope AVO can continue to grow – and grow together. There is much to be learned scientifically about volcanism in Alaska that has international application. With much-needed additional staff, AVO would be better equipped to write reports on all eruption responses (I tried to write up my logs after each response but found myself just heading into the next one time after time! Thanks to those who at least wrote up the annual summaries of AVO responses.) AVO has much to do to enhance hazards assessments, near real-time monitoring, and hazards communications as population and the air traffic industry continue to grow. You have a vital role and a well defined mission. I wish you well.

Terry E.C. Keith

Goodbye Terry, We'll miss you!! ☹

Eruptions

Summary

Alaska's volcanoes were unusually inactive from September through December, 1999 whereas several of the volcanoes of Kamchatka were restless during this reporting period.

Shishaldin Volcano
54°45' N, 163°58W

Although the recent eruptive activity at Shishaldin volcano had subsided by early summer, low-level seismicity continued through the end of the year culminating with a sudden, brief rise in seismic activity during the last few days of December. This short-lived episode was not accompanied by eruptive activity and AVO received no reports of unusual activity from pilots or ground observers. No thermal anomalies have been recorded at Shishaldin since May of 1999 and the color code remains GREEN.

Great Sitkin Volcano
52°05'N, 176°08W

The new seismic network at Great Sitkin volcano recorded unusual seismic signals during a few hours on December 21, resembling that produced during small avalanches. An NWS observer in Adak reported a minor steam plume over the summit that day. The weather was clear and nothing was visible on satellite images.

Klyuchevskoi Volcano,Kamchatka
56°03'N, 160°39E

Klyuchevskoi volcano was upgraded to color code YELLOW on October 29 when shallow earthquakes and volcanic tremor was recorded during the previous several days. Gas and steam plumes rose 50 to 100 m above the summit with a plume to 1000 m, extending 49 km downwind on October 26. The color code was downgraded to GREEN on November 5. Later in the month, on November 24, an ash burst from Klyuchevskoi sent a cloud up to 6 km ASL (summit is 4750 m, figure 1a) the color code was raised to YELLOW on November 26. Seismicity remained above background accompanied by minor fumarolic activity through the week of December 24 when the color code was reduced to GREEN.

Sheveluch Volcano, Kamchatka

56°39'N, 161°21'E

On November 1, 1999, a small explosion, from the dome, produced a minor ash plume at Sheveluch volcano that rose to about 5 km ASL (summit elevation is 2447 m; figure 1b). The color code was raised to YELLOW on November 5. Seismicity remained above background until mid-November and on November 19, the color code was downgraded to GREEN. A 10-minute-long seismic event November 24 sent an ash cloud up to about 3 km ASL, which dissipated within an hour. These events were relatively minor and did not cause any damage or disruption of services.

Karymsky Volcano, Kamchatka

54°03'N, 159°27'E

Karymsky volcano has been in color code YELLOW most of the year with minor gas and ash explosions occurring daily that produce emissions 300 to 1000 m above the summit (elevation 1536 m). On December 19, restoration of a key seismic station (KRY) that had become inoperable in early December revealed that seismicity had returned to background levels and the color code was subsequently reduced to GREEN on December 24.

Game McGimsey

Figure 1: Shishaldin in it's last throes of eruption, December of 1999. Low-level seismicity continued through the end of December.

Figure 2: Ash plume above Klyuchevskoi Volcano, Kamchatka on November 24, 1999. Photo by Demyanchuk Yury Vladimirovich.

Figure 3: Explosive ash burst from Sheveluch Volcano, Kamchatka on November 1, 1999. Photo by Demyanchuk Yury Vladimirovich.

MONITORING

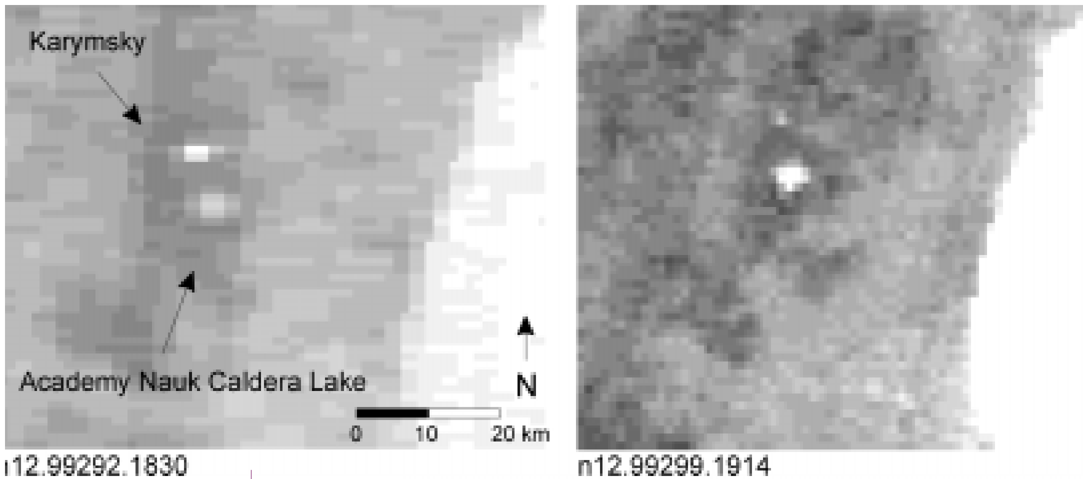
AVO monitors volcanoes in the Alaska and Kamchatka using the relatively high spatial resolution and nadir view of polar orbiting satellite data, and the high temporal resolution of geostationary satellite data. All of these systems include visible and thermal infrared wavelength data.

The Polar Orbiting system is the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA-12, -14, and –15 satellites. Images are recorded in five spectral bands at a spatial resolution of 1.1km at nadir. Imagery covering Alaskan and Kamchatkan volcanoes are received by the ground station at the Geophysical Institute, University of Alaska Fairbanks, and are analyzed twice daily to detect volcanic eruptions clouds and thermal anomalies at volcanoes in the North Pacific Region. Repetitive coverage by these satellites yield up to 12 images per 24 hours (6 near nadir) and ca. 4 images per 24 hours for Kamchatkan volcanoes. The timing of these satellite passes is not distributed evenly over a 24 hour time frame.

Geostationary data are received from the GMS (geostationary meteorological satellites) and GOES (geostationary operational environmental satellite) satellites via computer networks at AVO-Anchorage, and provide off-nadir observations of the western North Pacific (GMS) and eastern North Pacific (GOES). Hourly GMS data (~8km resolution at 60°N in the visible and thermal infrared) are available for analysis within 1 hour after reception by a ground station. GOES data are available at 15 minute intervals at resolutions of ~2km at 60°N (visible band), and at 30 minute internals at ~8km resolution (visible and thermal infrared bands), respectively within 45 minutes after reception by a ground station.

In August, Shelly Worley left to finish her degree in the Professional Communications Department, and our summer intern, Monica Theilen ended

Figure 4: Imagery of Karymsky volcano and its thermal anomaly, and the Academy Nauk Caldera lake to the SE. The left image, on October 19th shows the volcano hotter than the lake. In a later image (October 26th), the volcano was perhaps caught between bursts, and the lake shows a brighter signal due to increasing contrast to darker, colder background temperatures.



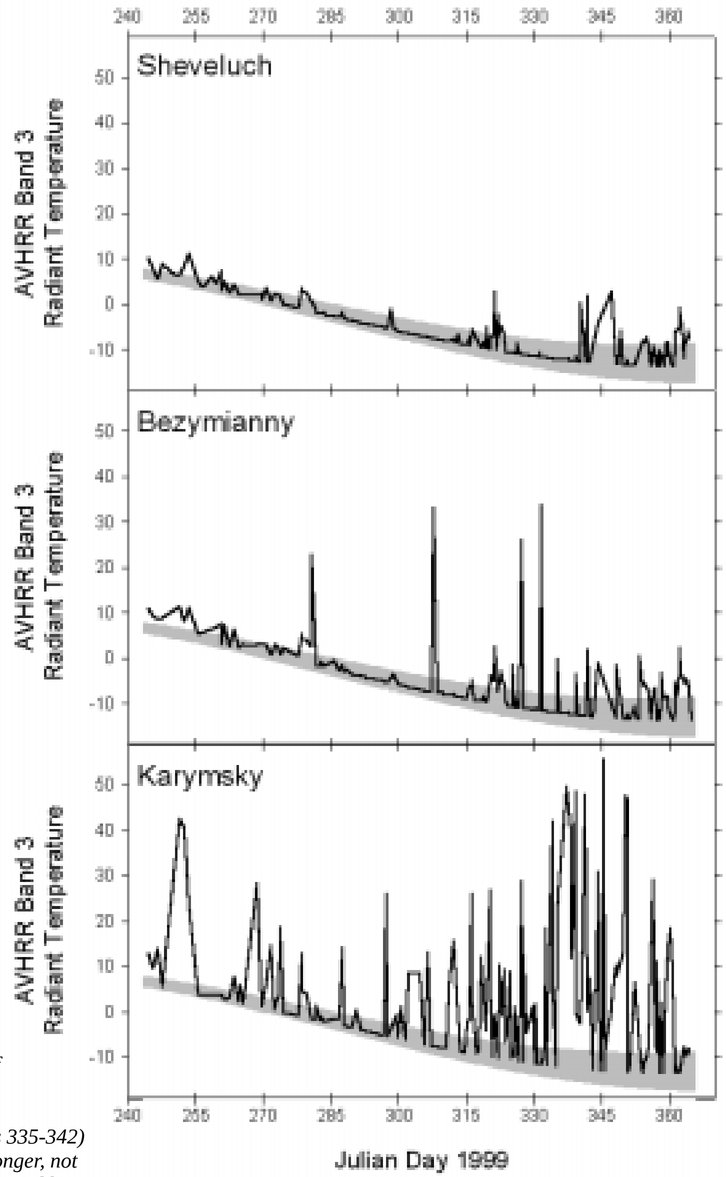


Figure 5: "Okmok Algorithm" time series plots for the active volcanoes in Kamchatka through this monitoring period. Sheveluch shows only slight increase in thermal temperatures (ca. Julian Day 323) just before a small steam plume was detected in thermal imagery (November 23rd). At Bezymianny the intermittent spikes are typical of the resitve lava dome. No significant thermal signal was seen proceeding the small plume on December 8th (Julian Day 342). At Karymsky the intermittent strombolian activity is seen as the spikes in the early part of the monitoring period. In early December (days 335-342) the signal is stronger, not reaching background between peaks. This may represent activity of the currently active lava flow.

her tenure at AVO. Both are and will be missed. Two new masters students joined the group in August, Ken Papp and Matt Patrick. Throughout this monitoring period Ken and Matt were learning AVO satellite monitoring techniques, and providing fresh insight into day to day operations.

In September, the Fairbanks satellite monitoring group received new accommodations in the Geophysical Institute. The change in rooms and offices caused only a minimal interruption of satellite monitoring thanks to the extra efforts of Kevin Engle to make a smooth transition.

Y2K issues were also under consideration during this monitoring period. Our monitoring software still retains a Y2K problem in that the year is given in a two digit number, both in archived images, and those currently being received. Several "work-arounds" were developed and are still in use pending a software upgrade being prepared by Sea Space. There was no loss of data, nor problems in data analysis as a result of the Y2K transition.

Volcanic Eruption Observations

During this period thermal anomalies dominated the observations with persistent "hotspots" at Karymsky and Bezymianny in Kamchatka, and transient anomalies at Opala (Kamchatka), Martin, Iliamna, and Trident (Alaska). The geothermally heated lakes at Karymsky (Academy Nauk Caldera) and Katmai were observed. Plumes were observed at Bezymianny and Sheveluch volcanoes in Kamchatka. The enthusiasm and sharp eyes of the new staff detected thermal anomalies at Opala in Kamchatka and Martin, Iliamna, and Trident in Alaska that are thought to have been solar reflections. A suspicious cloud at Vsevidof was further analyzed and thought to be orographic and/or jet contrails. A summary of the volcanic activity recorded in satellite imagery is given in table 1.

Karymsky Volcano

Activity continued after the renewal of the eruption in August of 1999 (Vol.11Nos. 3&4). The intensity of the thermal anomaly varied widely, and did not reach saturation levels for the AVHRR sensor until December 3rd in image n15.99337.0720. A table of the anomalies at Karymsky shows this variability, peaking in early December, and then decreasing in intensity through the end of the month (table 2, figure 4).

Karymsky has not been this active over such a long period since late

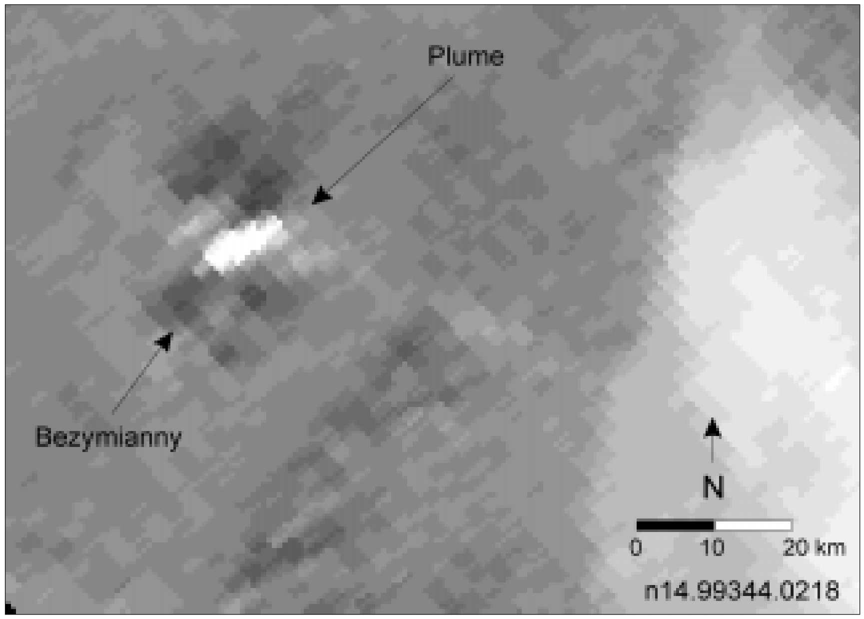


Figure 6: AVHRR band 3 image of the small observed at Bezymianny on December 8th. The bright ash-poor plume stretches to the NE for about 10 km.

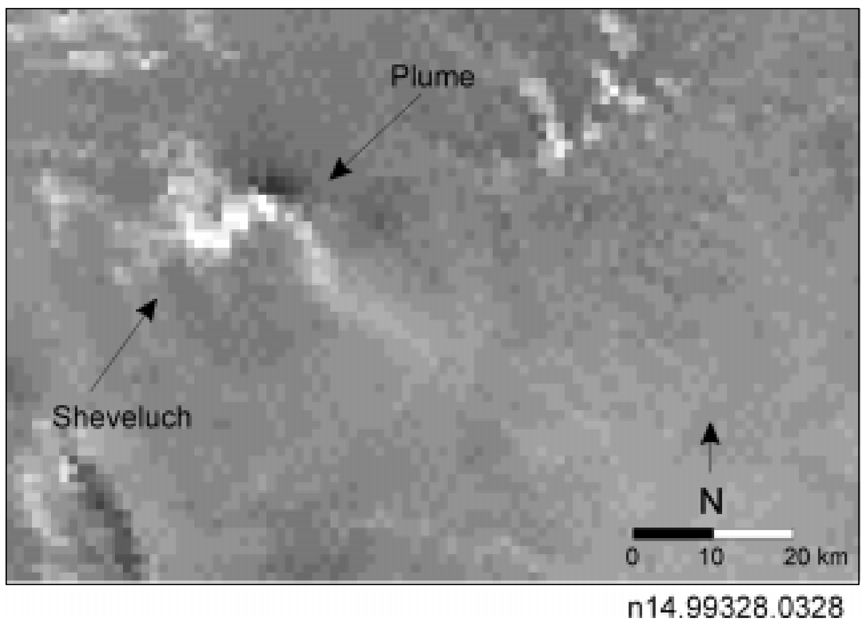


Figure 7: This small plume at Sheveluch on November 23rd was detected in AVHRR band 3 imagery after an alert from KVERT. The faint plume is ash-poor, and extends to the East for about 15 km.

1998. It is not clear whether this activity represents the lava flow observed by AVO staff while at the volcano last August, intermittent strombolian bursts, or a mixture of both. The Okmok Algorithm times series displays dominantly strombolian activity as random spikes over time, such as at Karymsky in 1998 and early 1999. The random spikes are a function of the semi-periodic nature of the volcanic activity, and the timing of satellite passes, and the mostly random nature of the cloud cover. For this monitoring period, the time series shows the "spiky" random look of strombolian activity, however, in late November, the data between spikes on the chart do not approach background levels (figure 5). This continuous high temperature signal is more consistent with a regular hot source on the ground, like a lava flow. For Hawaiian-style eruptions in the region, such as at Okmok in 1997, the AVHRR band 3 sensor reached and maintained saturation during the active extrusive phase of the lava. At Karymsky this level isn't quite that

continued

Table 1.
Satellite Observations of Alaska and Kamchatka Volcanoes for the Months of September-December 1999

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
September																															
Uzon		X																													
Karymsky															X	X		X	X			X							X		
Iliamna					X																										
October																															
Karymsky				X		X											X	X					X	X		X		X	X	X	
Academy Nauk Caldera																				X				X		X			X	X	
Katmai Lake																												X			
November																															
Opala																		X													
Karymsky		X	X		X		X		X	X	X	X		X	X			X													
Academy Nauk Caldera		X	X		X		X		X			X			X					X	X	X	X				X	X	X	X	
Sheveluch																							P								
Martin												X																			
Katmai Lake								X												X											
December																															
Academy Nauk Caldera																											X	X	X	X	
Bezymianny									XP																		X	X			
Ushkovsky																X															
Katmai Lake				X									X	X	X	X															

X = Thermal anomaly
P = Plume or suspicious cloud

Table 2:
Karymsky Volcano Imagery—September-December 1999

image	date	max. T (°C)	background T °C	ΔT	size (pixels)	comment
n15.99257.0720	15-Sep	14	-7	21	3	
n12.99259.1856	16-Sep	22	0	22	2	
n15.99261.0732	18-Sep	14	1	13	1	
n15.99262.0709	19-Sep	23	5	18	1	
n15.99265.0744	22-Sep	28	-3	31	3	
n12.99272.1906	29-Sep	23	3	20	1	
n12.99277.1854	4-Oct	7	-10	17	4	
n14.99279.1636	6-Oct	22	-2	24	2	
n12.99290.1904	17-Oct	5	-27	32	3	
n12.99291.1842	18-Oct	7	-14	21	3	
n15.99293.0722	20-Oct	3	-9	12	5	Lake
n12.99296.1830	23-Oct	36	-1	37	3	
n15.99297.0734	24-Oct	12	-6	18	3	Lake
n12.99299.1914	26-Oct	-6	-13	7	1	Lake
n15.99301.0746	28-Oct	4	-7	11	2	
n15.99302.0722	29-Oct	8	-8	16	1	Lake
n12.99303.0536	30-Oct	8	-8	16	2	Lake
n14.99306.1631	2-Nov	-6	-12	6	2	Lake
n12.99307.0547	3-Nov	4	-8	12	1	Lake
n14.99309.0354	5-Nov	9	-4	13	1	Lake
n15.99311.0722	7-Nov	4	-12	16	3	Lake
n14.99313.1652	9-Nov	-3	-15	12	2	Lake
n14.99314.1641	10-Nov	22	-14	36	4	
n12.99314.1828	10-Nov	-9	-16	7	3	
n15.99315.0734	11-Nov	3	-11	14	1	
n12.99316.0546	12-Nov	-2	-14	12	2	
n12.99318.1839	14-Nov	-2	-15	13	8	Lake
n15.99320.0722	15-Nov	-1	-16	15	2	Lake
n12.99322.0510	18-Nov	29	-11	40	9	
n15.99324.0734	20-Nov	0	-14	14	5	Lake
n12.99325.0545	21-Nov	-6	-20	14	10	Lake
n12.99326.1900	22-Nov	-3	-16	13	7	Lake
n14.99328.0338	23-Nov	-1	-14	13	6	Lake

Table 2. A list of selected imagery displaying the thermal anomaly at Karymsky Volcano and the Academy Nauk Caldera Lake. The lake, first noted in imagery on October 2nd, appears more common in imagery as the monitoring period progresses. The anomalies with large pixel areas (i.e. more than a few) are likely the lake, and usually display lower temperatures.

high, but this signal might be characteristic of higher viscosity, lower areal coverage lava flows.

Bezymianny Volcano

Beginning on December 9th, a thermal anomaly and ash poor plume were seen in image n14.99344.0358 (figure 6). This small eruption did not give as much warning as Bezymianny has in the past few years. A thermal anomaly, likely corresponding to unrest of the lava dome were seen on December 27th and 28th, 16°C and 9 °C above background respectively. The automated band 3 plot (figure 5) shows typical behavior for Bezymianny, most temperatures within background levels and few occasional spikes. There is no clear increase in temperatures before the plume emission on the 9th of December (Julian Day 343). The spikes on October 7th (day 280), November 3rd, 23rd, and 26th (days 307, 327,331), are likely just good views of the restive central lava dome. The larger noise signal at the end of the year is typical for all the plots, and not indicative of volcanic processes.

Sheveluch Volcano

A small burst of activity was reported for Sheveluch by our colleagues at KVERT on the 23rd of November. After this notification a faint plume was observed in image n14.99328.0338 (figure 7). No thermal anomaly was detected before or after this eruption. This is not unusual since the amphitheater at Sheveluch is open away from Fairbanks, and its distance makes it difficult to obtain a satellite pass with a low zenith angle capable of peering over the rim to the lava dome. The automated “Okmok Algorithm” did show a cluster of slightly warmer values (ca. 2-7 °C above background) in band 3 radiant temperature preceding the small burst, from Julian Day 321 to 325 (November 17th-21st).

Geothermal Lakes

During this time of year, decreasing ambient temperatures near geothermal lakes, whose temperature remains relatively constant, allow these lakes to suddenly appear in satellite imagery. The two most common lakes to be seen in the North Pacific are the caldera lake near Karymsky Volcano in Kamchatka, the Academy Nauk Caldera Lake, and Katmai Lake in Alaska.

The Academy Nauk Caldera Lake was seen in several images, starting on the 2nd of November. For many observation periods, the Lake was seen in tandem with the nearby activity at Karymsky Volcano. However, on several occasions, the Lake and not the Volcano was the dominant thermal feature of the area (November 14th, and November 20th-23rd). Typically the Lake is only a few degrees (5-10°C) above background, but increases (>15°C) as background temperatures decrease.

Katmai Lake was first noted in observation reports on October 28th. It was noted several times in imagery on November 8th, 20th, and sporadically in December. The lake was 5-20 °C above background temperatures.

Other Activity

Anomalies and suspicious clouds were recorded at several other volcanoes and locations during the monitoring period. Most of these have since been attributed to other, non-volcanic sources.

At Uzon volcano in Kamchatka, a 2 pixel thermal anomaly, 35°C degrees above background was noted on September 2nd in image n12.99245.0529. This anomaly was likely a fire near the volcano.

A thermal anomaly was observed at the summit of Iliamna Volcano. Similar but less pronounced anomalies were noted at Augustine, Katmai and Trident on September 5th. These anomalies also turned out to be solar reflectance.

Martin Volcano showed a single pixel thermal anomaly on November 12th. This anomaly was 50°C above background (image n15.99306.0530), in a night-time image. There is instrument noise in the image but none within hundreds of kilometers of the volcano. The volcano also has an active fumarole field. No other activity was seen at the volcano during the monitoring period.

At Opala Volcano (Kamchatka) a thermal anomaly was detected on November 18th. This anomaly as well seems to be solar reflectance.

A short lived ash burst was reported at Klyuchevskoi Volcano (Kamchatka) by the ‘air control center’ at Petropavlosk on the 24th of November. No thermal anomaly or plume was visible in the AVHRR imagery from that time period, and the conditions were quite clear, showing the volcano and its neighbors plainly. The Tokyo VAAC issued a warning, but noted that the plume could not be confirmed in satellite imagery.

Jon Dehn, Ken Dean, Dave Schneider, Kevin Engle, Ken Papp, and Matt Patrick