

# Development and Implementation of an Environmental Satellite-Monitoring Database System

6<sup>th</sup> Polar Remote Sensing Conference  
Seward Alaska 2006

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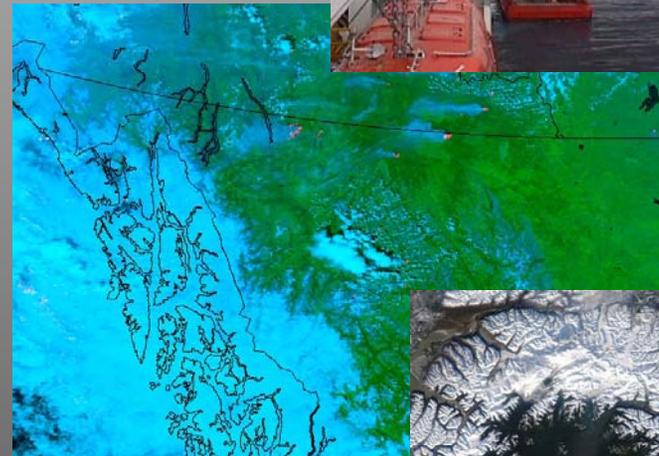
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2 Alaska Volcano Observatory, U.S. Geological Survey, Anchorage, Alaska, USA.

# Remote-Sensing Information and Use Has Grown Significantly in Recent Years

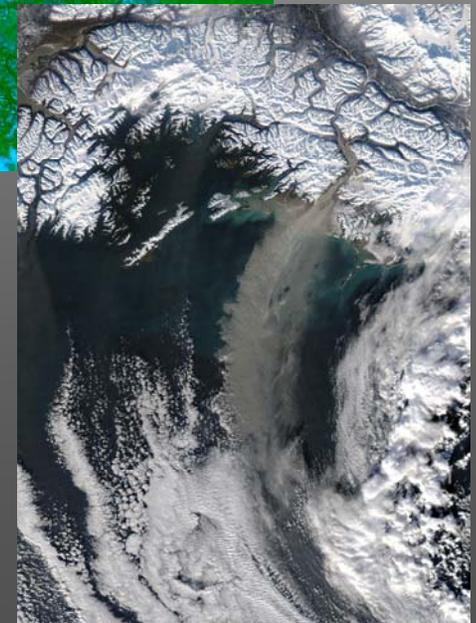
## Data

- Satellites
- Ground-based Systems (e.g. Web-cams)
- Data Volume
- Data Access
- Data Distribution



## Real-time Monitoring and Analysis

- Forest Fires
- Hurricane Damage
- Flooding
- Pollution
- Volcanic Eruptions



## Problem/Solution

- Information Saturation
- **Database Monitoring System**

# **Case Study: Database Monitoring System**

**Subject: Volcano Monitoring in the North Pacific Region**

**Development: Satellite Section Alaska Volcano Observatory (AVO),  
Geophysical Institute, University of Alaska Fairbanks**



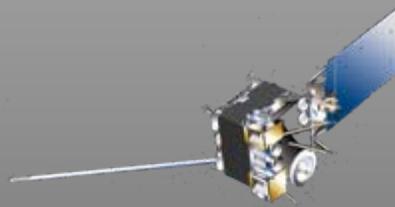
# Why do we need a database monitoring system?

↑ **Satellites**  
(Number used for monitoring and yr added to AVO system)



1989: AVHRR

Cumulative  
# of satellites  
5



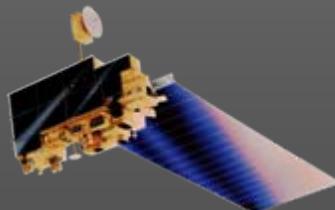
1997: GOES  
(Images sub-hourly)

6



1997: GMS/MTSAT:  
(Images sub-hourly)

7



2000: MODIS:

9

# Why do we need a data base monitoring system?

↑ Satellites



1989: AVHRR  
2.5 GB/day

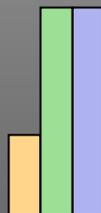
Cumulative  
Total Vol./day  
2.5 GB

↑ Data volume  
Daily Cumulative  
Dates Added to AVO



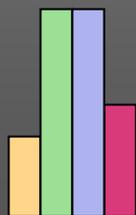
1997: GOES  
10.5 GB/day

13 GB



1997: GMS/MTSAT:  
10.5 GB/day

23.5 GB



2000: MODIS  
4.5 GB/day

28 GB

# Why do we need a data base monitoring system?

↑ Satellites

↑ Data volume

↑ Use of Webcams

(how and where do we report observations and keep archive)

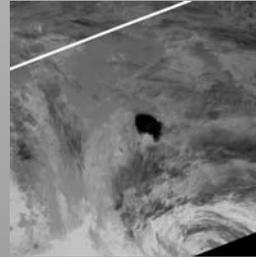


Augustine Island Thu Jan 12 11:33:41 2006 Ex: 300



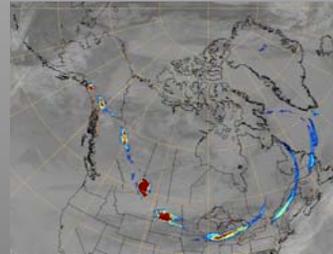
# Why do we need a data base monitoring system?

↑ Satellites



**1990: Seismic detects activity but is there an Eruption, Plume?**

↑ Data volume



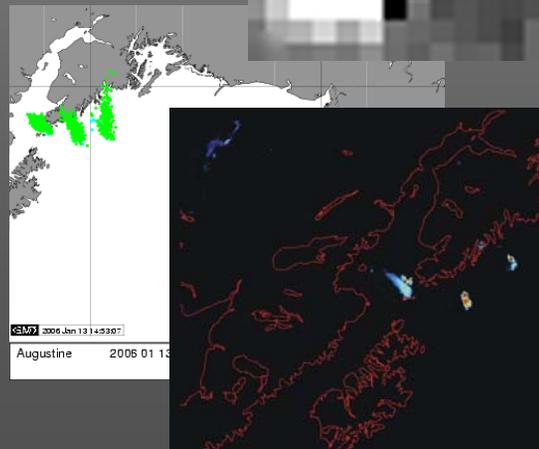
**1992: Satellite detects Plume and tracks movement**

↑ Use of Webcams

↑ Analysis Capabilities



**1997: Quantitative Measurements: ash signal, temps., thermal flux, etc.**



**1998: Prediction of ash movement**

# Why do we need a data base monitoring system?

↑ **Satellites**

Satellite	# Bands	Passes/day	Images / day
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↑ **Data volume**

AVHRR	5	20	~ 100
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↑ **Use of Webcams**

GOES	5	96	480
------	---	----	-----

↑ **Analysis Capabilities**

MODIS	36	12	432
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↑ **Data Quantity**

Web Cam	1	~ *5 min.	<u>288</u>
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Number of images

Total # images analyzed per day : 1300

# Why do we need a data base monitoring system?

Satellites



Data volume



Cumulative



Use of Webcams

Analysis Capabilities

**Needed Consistency and  
Structured Reporting**

**Searchable information**

## 1997 Report:

Kamchatka was clear to the south, and Karymsky Lake was visible in image n14.97317.1608, as a ca. 9 pixel spot square, max temperature of -0.7 on a background of -10. The summit at Karymsky showed no thermal activity. This was the only activity observed.

## AM satellite report for January 18, 2006

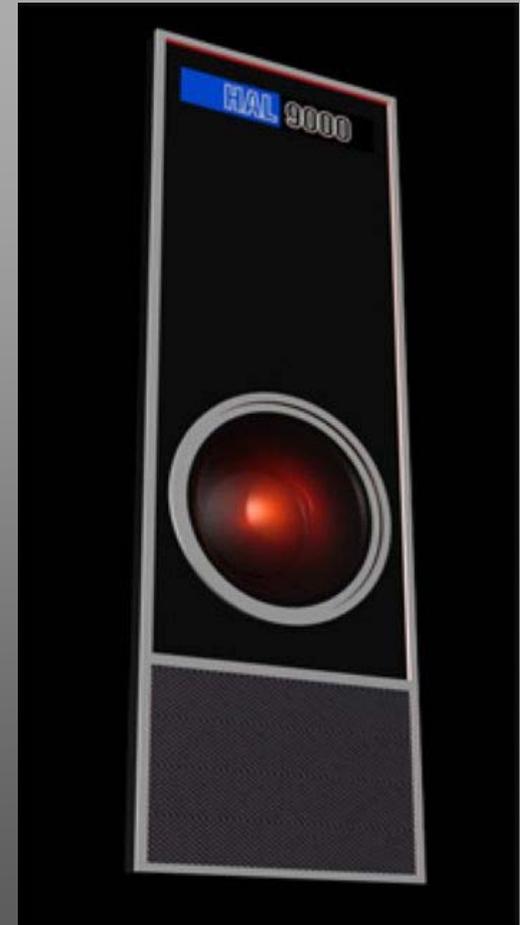
**SUMMARY:** Thermal anomaly at Augustine, thermal anomaly at St. Helens, thermal anomaly at Katmai

**COMMENTS:** Augustine hotspots seem to be tending to the east of the island.

**OBSERVATIONS:** Augustine (Red): Partly cloudy at volcano 1) Image n15.06018.1714 : mostly clear at volcano, sat zenith angle of 21.18 - ch3 hotspot: 3 anomalous pixels, peak reading of 42.4 C, background of -17.59 C

# AVO satellite database monitoring system

Two Components Running Simultaneously: Manual and Automatic



Automated Analysis: real-time as data received (satellite station and ground networks: NOAA, Navy)

# Manual Analysis Interface

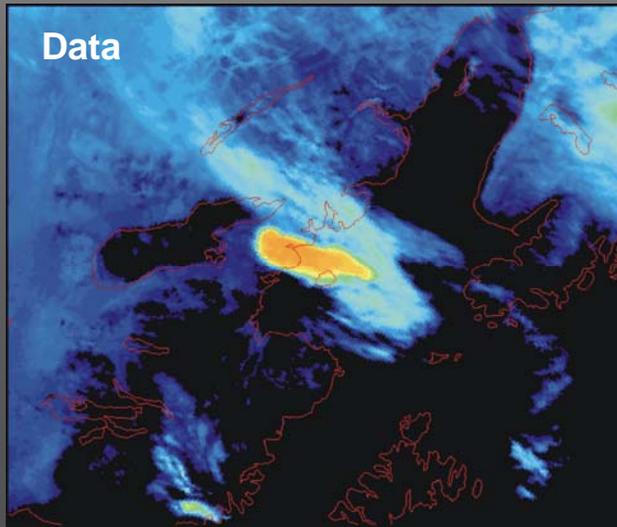
Information: Entered twice daily or more by students, staff and faculty

Entries: Web Interface

Preset categories must be filled in

Linked to: Satellite data receiving station and ground-based distribution systems

Searchable, & reports and graphics automatically generated and distributed (email)



## Database

<b>Cloud Temp.</b>	<b>Backgnd. Temp.</b>
Tx = -55C	Tb = -14C
<b>Plume Length</b>	<b>Plume Direction</b>
46 km	NW

## Message

AVHRR data at 1738 shows a plume with a temperature of ~-55 C which correlates to > 25,000' (8km). The leading edge of the cloud is drifting NW and about 46 km from the volcano.

# Manual Analysis Interface

Seismology **Satellite** Geodesy Geology VALVE PUFF Webcams Volcano Monitoring Weather Logs Calendars Web Tools



AVHRR  
subregions

MODIS  
subregions

Observation  
Database

Daily  
Logs

Okmok  
Algorithm

Volcano  
Locations

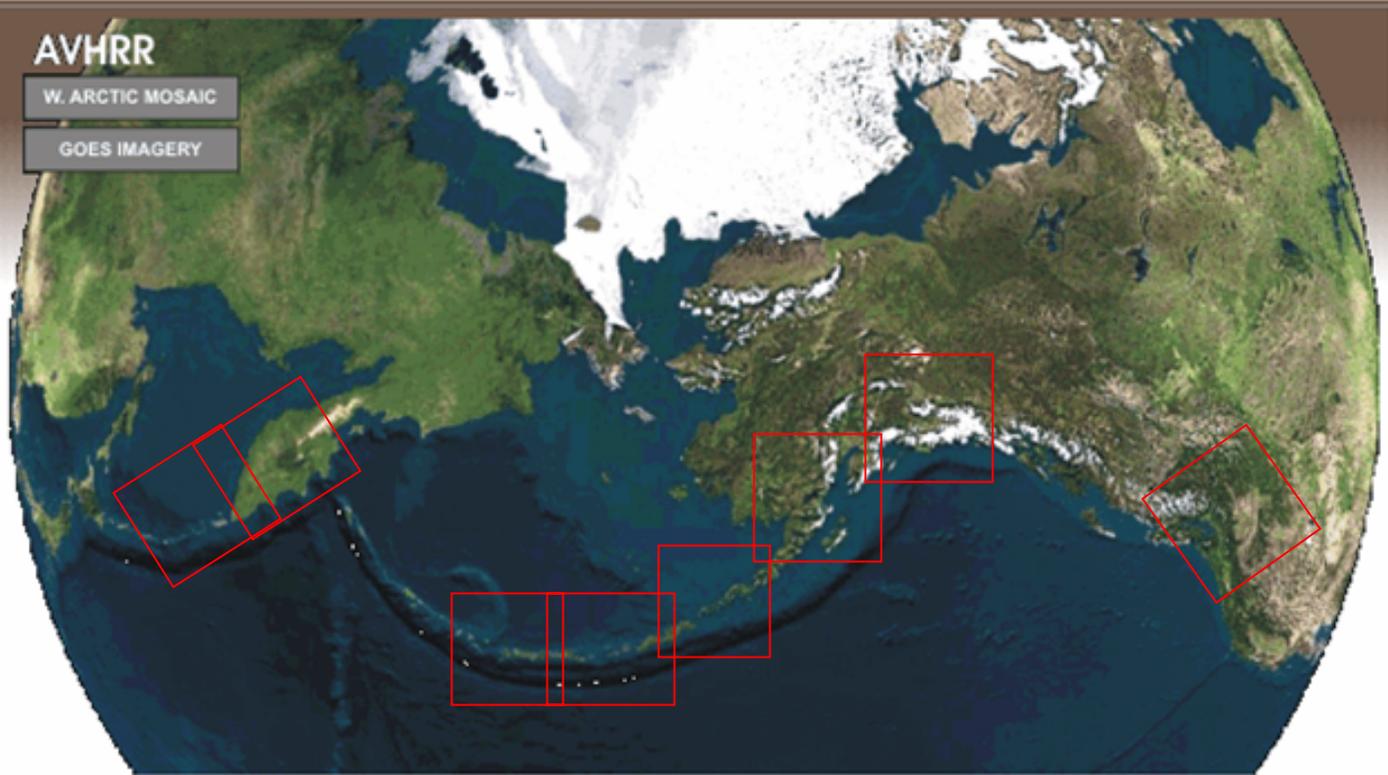
Links

Puff  
Models

Recent  
Eruptions

Contacts

ftp site/  
text only



CLICK ON A REGION TO LIST 4 DAY ARCHIVE OR CHOOSE A SPECIFIC IMAGE TO VIEW.

## Augustine Duty Remote Sensor

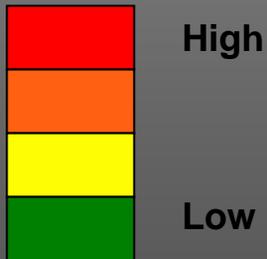
Jon Dehn :: [jdehn@gi.alaska.edu](mailto:jdehn@gi.alaska.edu)  
office 474.6499 :: home 458.9270 :: cell 322.0676

# Manual Entry: Base Page

**Base Observations:  
Primarily Clouds**

**Active volcanoes  
& sectors**

**Color Code  
Alert Level**



[Choose Observation](#)

Base Observations

[Satellite Observations](#)

[Camera Observations](#)

[Store Changes](#)

Cloud conditions for volcanoes with elevated color codes:

Volcano	Color Code	Cloud Cond
Augustine	Red	Mostly Clear
Martin	Yellow	Mostly Clear
Spurr	Yellow	Partly Cloudy
St. Helens	Orange	Cloudy
Bezymianny	Yellow	Cloudy
Ebeko	Yellow	Cloudy
Karymsky	Orange	Cloudy
Shiveluch	Yellow	Cloudy

Cloud conditions for each region:

Wrangell	Mostly Clear
Augustine	Mostly Clear
Pavlof	Partly Cloudy
Vsevidof	Partly Cloudy
Korovin	Mostly Cloudy
Kiska	Cloudy
Cascades	Mostly Cloudy
Yellowstone	Mostly Cloudy
Bezymianny	Mostly Cloudy
Kurile	Mostly Cloudy

Comments (?) :

Operational Notes:

Active plume in the air at the time of this monitoring. Puff modeling, plume temperatures compared to radiosonde and nexrad suggest plume heights of 8-10km.

GOES processing is suffering again, but the data is not lost and is being back-processed.  
Gilmore feed is having issues, thank goodness our AVHRR station is back.  
  
Veni webcam has timing issues (bright sunlight at 06:44).

# Manual Entry : Satellite Observations

Detailed  
Observ.

[Choose Observation](#)
[Base Observations](#)
Satellite Observations
[Camera Observations](#)
[Store Changes](#)

Start a new Observation (?) :

**Sector** **Volcano**

AVHRR | Augustine | Augustine

Local image (?) :  
(image)

Other image, or image range: (?) :  
(manual)

Select an Existing Observation (?) :

Veniaminof - t1.06017.0828

Augustine - g10.06017.1730

Augustine - n15.06017.0358

Augustine - n14.06017.1831

Augustine - t1.06017.0649

Augustine - n14.06017.0622

Augustine - g10.06017.1830

Expand Obs   Store Obs   Delete Obs

---

General Observations:

Cloud condition Mostly Clear

Zenith angle 40 (?)

Significant noise Y / N (?)

Comments for this observation:

47 km maximum distance from the volcano, bearing NW at 130 degrees. Plume has a long axis of 73 km angled at bearing 115. No split window at this time.

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Plume Observations: (add band)

*Blank lines are acceptable*

Band	Length <small>km</small>	Height <small>km</small>	Dir	Value <small>various units</small>	Review
ch4	73	8	115	-55	undefined <input type="checkbox"/>

Thermal Anomaly Observations: (add band)

*Blank lines are acceptable*

Band	Pixels	Orient	Value <small>various units</small>	Bckgnd <small>various units</small>	Review

# Manual Entry: Camera Observations

[Choose Observation](#)

[Base Observations](#)

[Satellite Observations](#)

Camera Observations

[Store Changes](#)

Start a new Observation:

Camera:

Volcano:

Image date:  (?)

Image end date:  (?)

Select an Existing Observation (?) :

Augustine - AugiCam - 06/01/17 09:59 UTC

Expand Obs

Store Obs

Delete Obs

General Observations:

Cloud condition

Plume Visible Y  / N

Thermal Visible Y  / N

Comments:

# Automated Reporting: E-mail Preview

Automatically  
generates  
E-mail report

Volcano Monitoring - Preview Your Email

<a href="#">Base Page</a>	<a href="#">Satellite Observations</a>	<a href="#">Camera Observations</a>	Preview Email	Send and Store
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Report is for: AM  or PM , yesterday  or today

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**Subject:** 17 January 2006 AM satellite report

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**From:** Ken Dean <kdean@gi.alaska.edu>

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**To:** avo\_ops@eq.giseis.alaska.edu, avo\_kvert@eq.giseis.alaska.edu

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AM satellite report for January 17, 2006

SUMMARY:  
No activity observed.

OBSERVATIONS:  
**ERROR:** You must specify weather for Karymsky.  
**ERROR:** You must specify weather for Bezymianny.  
**ERROR:** You must specify weather for Martin.  
**ERROR:** You must specify weather for Augustine.  
**ERROR:** You must specify weather for Spurr.  
**ERROR:** You must specify weather for Ebeko.  
**ERROR:** You must specify weather for St. Helens.  
**ERROR:** You must specify weather for Shiveluch.

CLOUD CONDITIONS:  
Wrangell: **(must be filled out)**  
Augustine: **(must be filled out)**  
Pavlof: **(must be filled out)**  
Vsevidof: **(must be filled out)**  
Korovin: **(must be filled out)**  
Kiska: **(must be filled out)**  
Cascades: **(must be filled out)**  
Yellowstone: **(must be filled out)**  
Bezymianny: **(must be filled out)**  
Kurile: **(must be filled out)**

LAST IMAGES VIEWED:  
AVHRR: **(must be filled out)**  
GOES10: **(must be filled out)**  
MODIS: **(must be filled out)**  
MTSAT1: **(must be filled out)**

# Automated Reporting: Distributed Message

AM satellite report for January 17, 2006

## SUMMARY:

Plume and thermal anomaly at Augustine, thermal anomaly at Veniaminof

## OBSERVATIONS:

Augustine (Red): Mostly clear at volcano

1) Image n14.06017.1831: partly cloudy at volcano, sat zenith angle of 68

- comments: edge pass, plume visible

- ch4 plume: 75km long, heading 130, observed at -47 C, est. 8km high

Martin (Yellow): Mostly clear at volcano

Spurr (Yellow): Partly cloudy at volcano

St. Helens (Orange): Cloudy at volcano

## CLOUD CONDITIONS:

Wrangells (Wrangell sector): Mostly Clear

Cook Inlet (Augustine sector): Mostly Clear

Alaska Peninsula (Pavlof sector): Partly Cloudy

Eastern Aleutians (Vsevidof sector): Partly Cloudy

## LAST IMAGES VIEWED:

AVHRR: 18:31 UTC

GOES10: 18:30 UTC

MODIS: 18:37 UTC

01/13/2006

# Extracting Information from the Database

## Alaska Volcano Observatory Observation Dumper

image_id	aquisition_datetime	ch20b	ch20b_bg	ch20b_pix	ch21b	ch21b_bg	ch21b_pix	ch22b	ch22b_bg	ch22b_pix
t1.06011.0726	2006-01-11 07:26:00	-4.5	-8	2						
t1.06013.2039	2006-01-13 20:39:00	21	-16	24				8	-13	24
t1.06013.2216	2006-01-13 22:16:00	21	-1	13				23	-3	12
t1.06014.0619	2006-01-14 06:19:00	24	-3	34						
t1.06014.0757	2006-01-14 07:57:00	27.7	-13	14						
a1.06014.1155	2006-01-14 11:55:00	30.5	-8.7	14						
a1.06014.1333	2006-01-14 13:33:00	10	-2	5						
t1.06016.2109	2006-01-16 21:09:00	12.95	-9.5	3				5.25	-15	1
t1.06017.0649	2006-01-17 06:49:00	10.25	-18	4						
t1.06017.2152	2006-01-17 21:52:00	33	-9	7						
t1.06018.0732	2006-01-18 07:32:00	58.84	-14	5				53.21	-13	5
a1.06018.1308	2006-01-18 13:08:00	15.64	-15.09	4						
t1.06019.0637	2006-01-19 06:37:00	1.94	-15.8	5						
t1.06019.0815	2006-01-19 08:15:00	-1.41	-17.53	5				-3.84	-16.96	5
a1.06019.1214	2006-01-19 12:14:00	6.23	-18.65	3				2.08	-18.2	3

# Automated Reporting: Weekly Activity Table

Alaska Volcano Observatory  
Weekly Report

week to view

2006

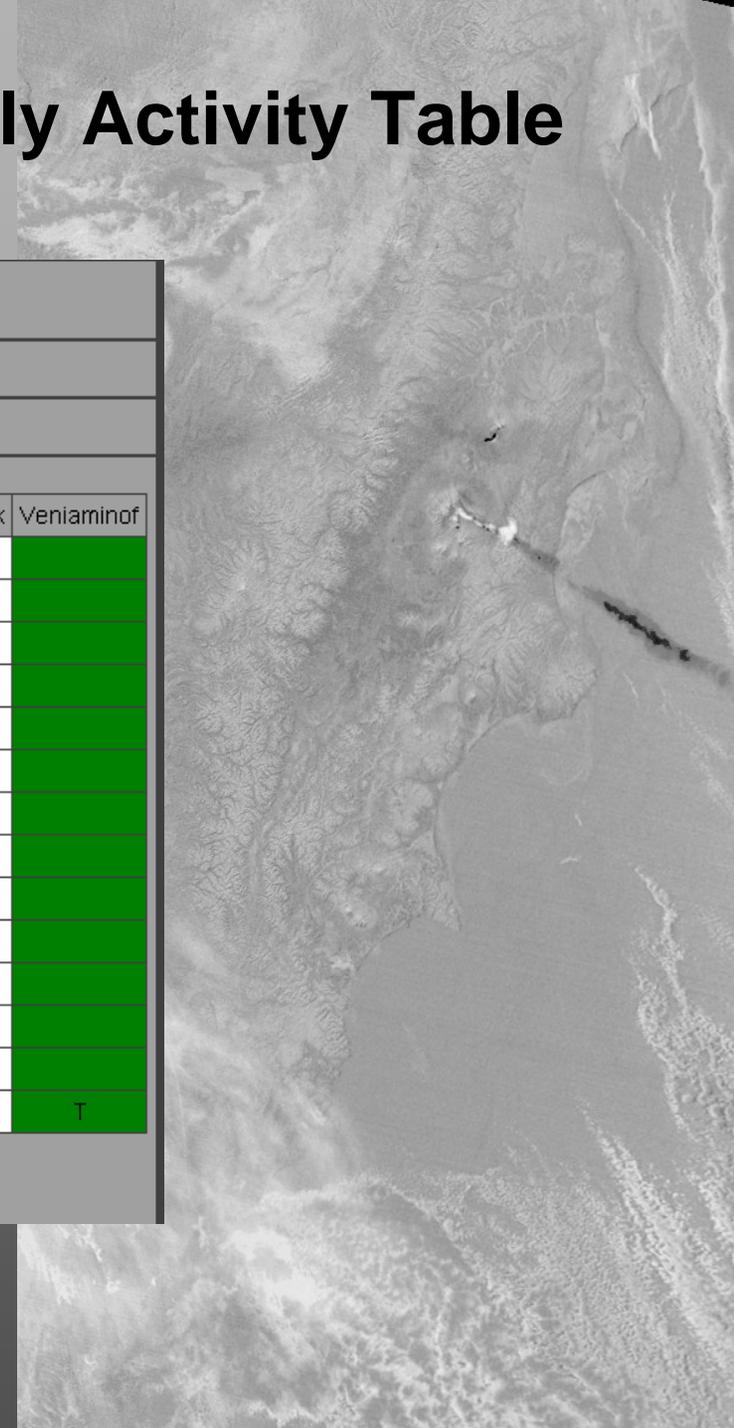
2006-Jan-10 to 2006-Jan-17

display

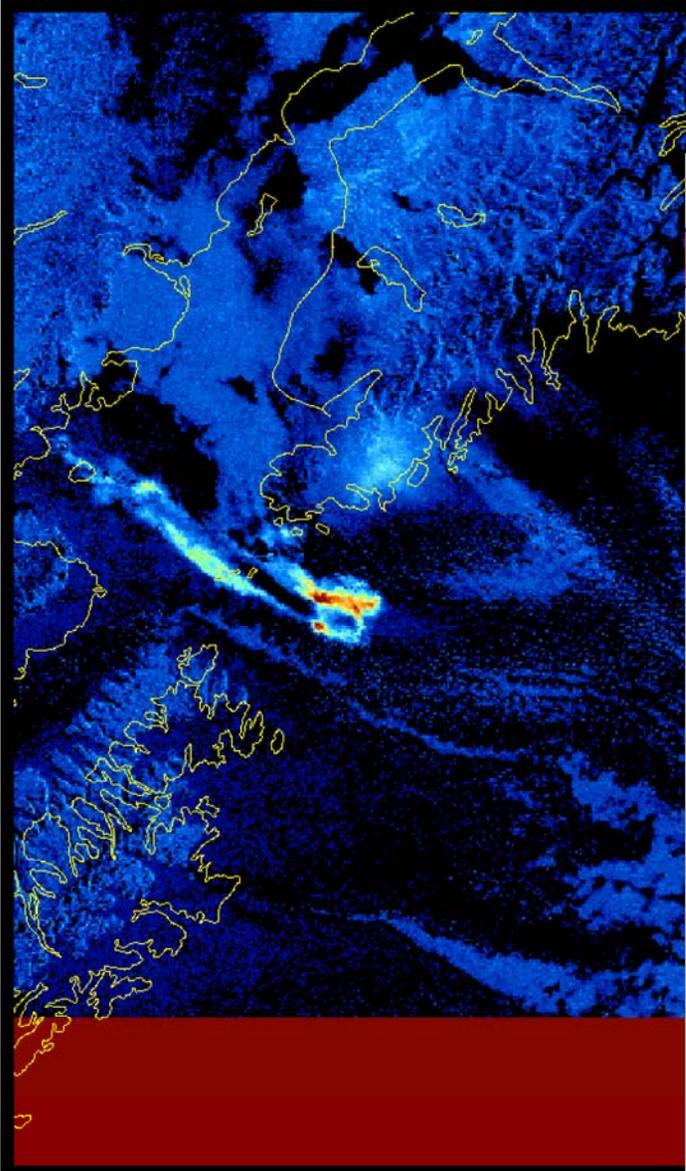
detailed

		Augustine	Bezymianny	Ebeko	Karymsky	Martin	Shiveluch	Spurr	St. Helens	Tolbachik	Veniaminof
day 10	PM				T		T				
day 11	AM	PT	T		T		T			T	
	PM	T			P						
day 12	AM	PT	T				T				
	PM	P			P						
day 13	AM	PT									
	PM	PT			T						
day 14	AM	PT			T						
	PM										
day 15	AM				T						
	PM										
day 16	AM										
	PM	T									
day 17	AM	PT									T

Report is for 2:00 PM on the starting Tuesday till 2:00 PM on the following Tuesday.  
Events are presented according to the time of observation, not time of acquisition.



# Automated Reporting: Bimonthly Table of Activity



Alaska Volcano Observatory  
Bi-Monthly Report

period to view

2005

November and December

November	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
Bezymianny							X	X					X	X	X	X	X	X	X	X	X					X		XP	X	XP
Cleveland				X	X	X																								
Karymsky	X		X	X			XP										X	X	X	X	X		X	X	X	X		X	XP	
Katmai			P		XP					P																				
Koryaksky																				X										
Shiveluch			X				X	X					X	X	X	X	X	X	X	X	X		X						XP	X
Spurr			P							P																				
St. Helens							X	X	X	X				X	X		X	X	X	X	X	X	X							
Tolbachik														X			X			X									X	
Veniaminof				P												P	P													

December	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
Akademia Nauk					X																										
Augustine												P					P														
Bezymianny							X	X	X															X	X				X	X	
Karymsky				X	XP	X	XP	XP	XP	XP				X	X	X	X	X	X			X	XP	X	XP	X	X			X	
Kliuchevskoi							X																								
Semisopochnoi																											X				
Shiveluch							X	X	X								X	X						X					X	X	
St. Helens					X		X	XP	XP	X	X	X	X	X	X	X	X	X													

X - hotspots  
P - plumes, ash bursts

# Automated Analysis Systems

## Types:

- Hot Spot Detection
- Ash Cloud Detection
- Data Reception Analysis

## Automated Linkage:

- Satellite data receiving station
- Ground-based distribution systems

**Automated alert minutes after satellite pass**

**Database Entry**

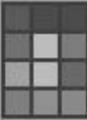


# Hot Spots: Okmok II Algorithm

## Hot Spot Report

- Searches
- Extracts
- Database Entry

Alaska Volcano Observatory Hotspot Report		
Start Date	2006/5/2 (?)	4 hotspots <a href="#">show hotspots</a>
End Date	2006/5/2 (?)	
Volcano	Kliuchevskoi	
Volcanoes Targeted	Bezymianny, Kliuchevskoi, Ushkovsky	
Time Zone	<input type="radio"/> AK / <input type="radio"/> UTC	

hotspot	image	subsector	volcanoes	sun zenith angle	sat zenith angle
	n16.06122.1617 <a href="#">view</a>	Kliuchevskoi	Bezymianny Kliuchevskoi Ushkovsky	98	49
	n18.06122.1502 <a href="#">view</a>	Kliuchevskoi	Bezymianny Kliuchevskoi Ushkovsky	100	41
	n14.06122.0858 <a href="#">view</a>	Kliuchevskoi	Bezymianny Kliuchevskoi Ushkovsky	92	40
	n15.06122.0545 <a href="#">view</a>	Kliuchevskoi	Bezymianny Kliuchevskoi Ushkovsky	65	25

# Hot Spots: Okmok II Algorithm

## Observation Viewer

- Shows 40x40 image
- Statistics

Alaska Volcano Observatory  
Automatic Observation Viewer

Start date: (?) 2005/1/1

End date: (?) 2005/6/1

Subsector: Kliuchevskoi

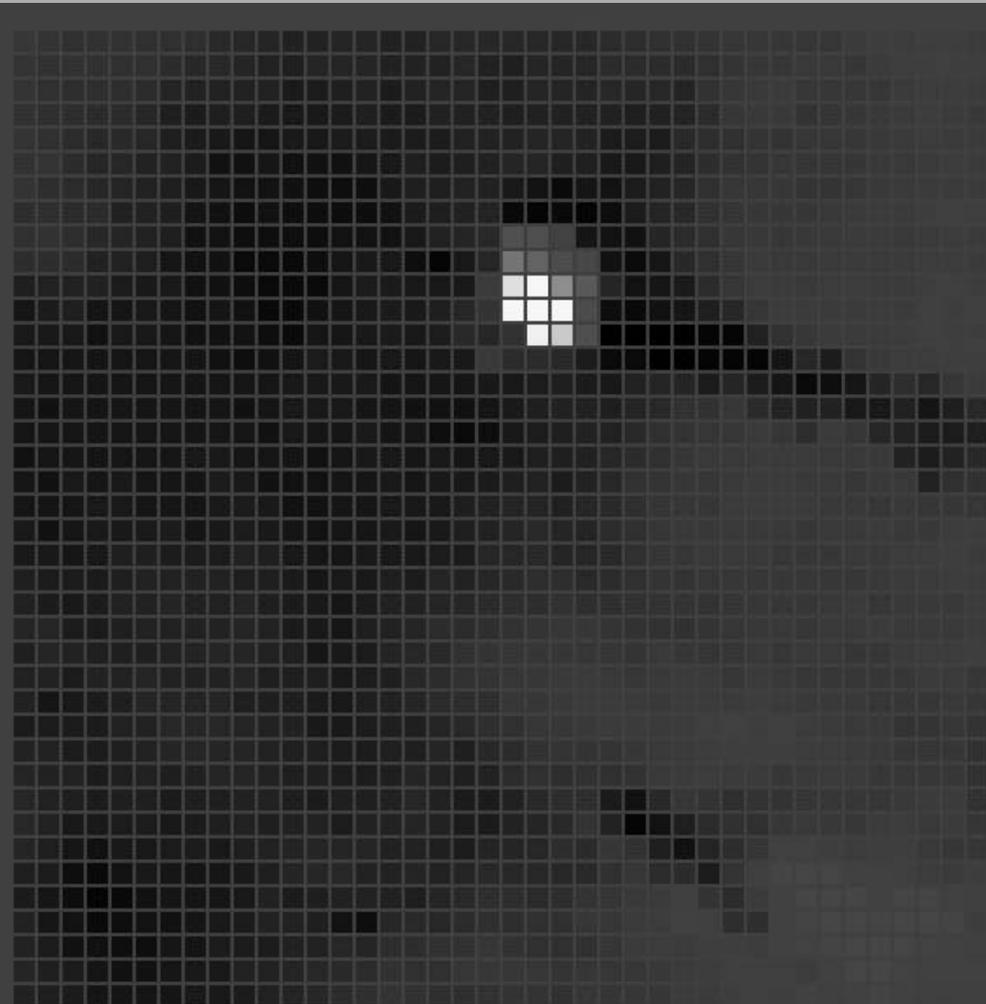
Image: -- n17.05075.1058 +

Band: ch3

High trim: auto -- 60 +

Low trim: auto -- -40 +

property	value
value at mouse	-31.28
max	56.85
min	-45.3
mean	-24.77
stddev	4.96
sun zenith angle	100
sat zenith angle	11
automatic evaluation	acceptable
target volcanoes	Bezymianny (colorless) Kliuchevskoi (colorless)
collateral volcanoes	Ushkovsky (colorless)



Key (some items can be toggled by clicking on them)

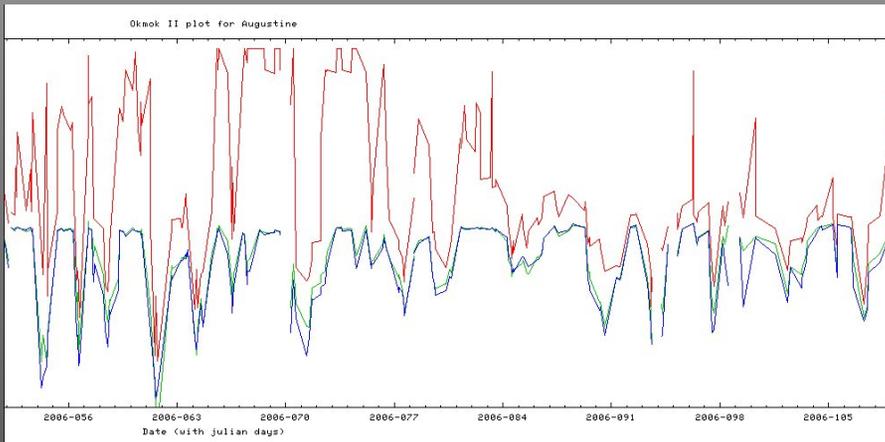
data and NaN	hotspot	deviant	solar	solar cloud	cloud	
pixel data received	off	off	on		off	

# Hot Spots: Okmok II Algorithm

## Graphic Analysis Temperature Flux

Shows Relative Change over time

Temperature Degrees C



Julian Date

[Prefab Queries](#)

[Basic Queries](#)

Advanced Queries

[Bulk Queries](#)

Volcano	Augustine
Volcanoes Targeted	Augustine
Start date	(?) 2006/1/1
End date	(?)
Platform types	<input checked="" type="radio"/> AVHRR / <input type="radio"/> MODIS
Subsector restrictions (applied to subsector data)	<p>blank line - low sat zenith - night pass</p> <p>sat_zenith_degrees &lt;= 40 <a href="#">remove</a></p> <p>sun_zenith_degrees &gt;= 90 <a href="#">remove</a></p>
Subsector data series (plot subsector data)	<p>blank line - primary bg - cloud bg</p> <p>ch3_mean <a href="#">remove</a></p> <p>ch3_max <a href="#">remove</a></p> <p>ch4_bg_mean <a href="#">remove</a></p>
Hotspot restrictions (applied to hotspot candidates)	blank line - near saturation
Hotspot data series (plot hotspot candidates)	blank line - primary max - cloud max
Data presentation	<input checked="" type="radio"/> values / <input type="radio"/> change
Axis label	YYYYDDD.HHMM
String for invalid data	NaN

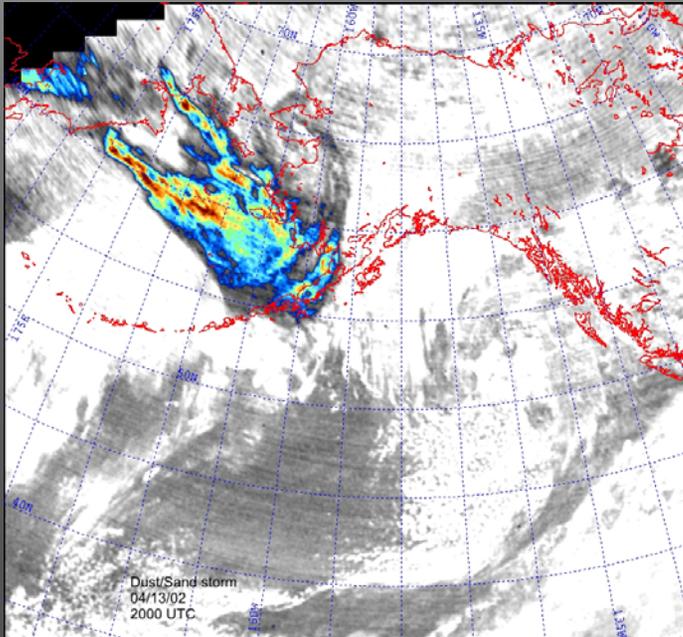
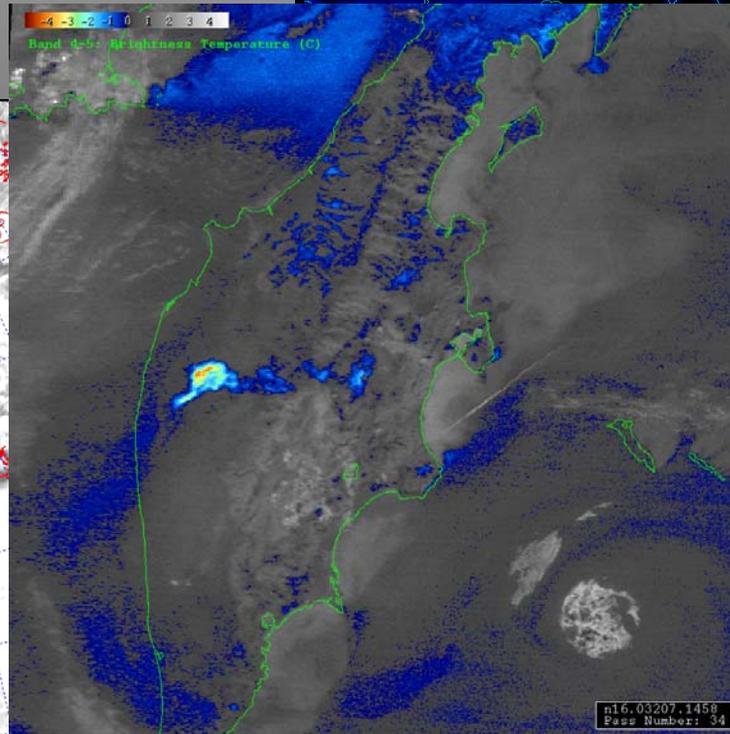
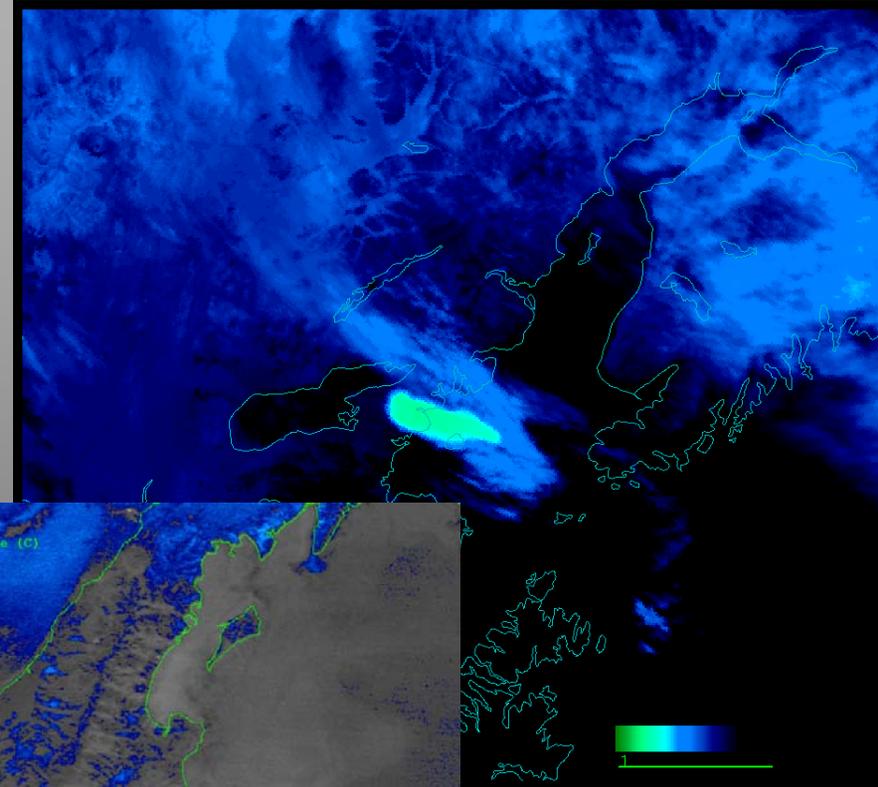
# Ash Cloud: Cleveland Algorithm

## Version 1.

- Airborne Ash
- Works for GOES Data only
- Large eruptions only

## Version 2. Underdevelopment

- All data
- Different Logic Tree
- Many False Alarms



Errors  
Weather Cloud  
Opaque Cloud  
Dust

# Manual Vs. Automated Systems

## 1. Manual

### Advantage:

- eliminates most false alarms
- can compensate for variable environmental conditions
- more encompassing analysis (not to specific feature)
- **excellent training tool for students**

### Disadvantage

- qualitative observations
- not always timely (not a 24 hr. shop; but on call 24 hr)

## 2. Automated

### Advantage:

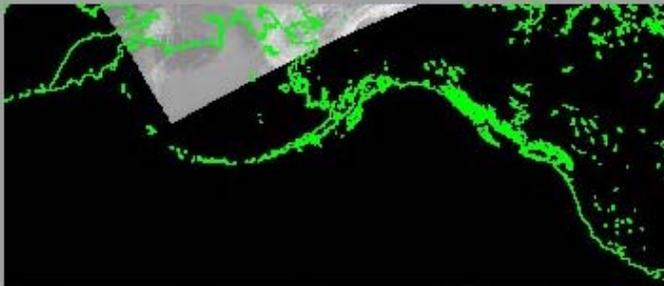
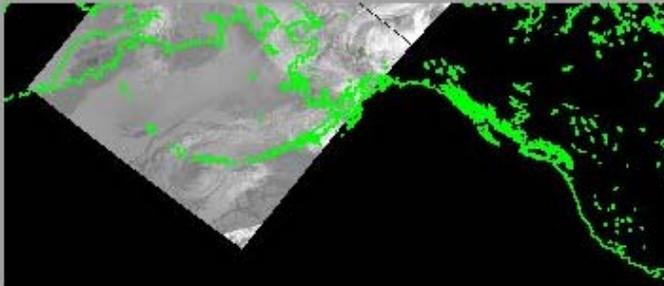
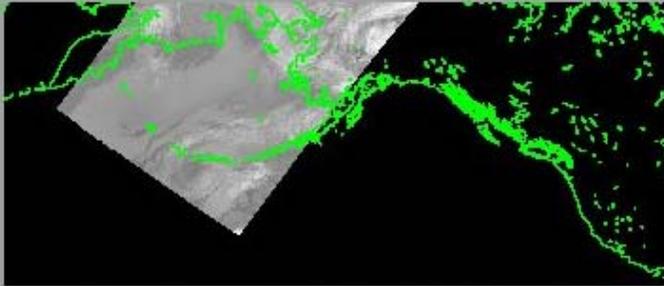
- rapid analysis in real-time (minutes after pass)
- quantifiable observations
- consistent and structured reporting system

### Disadvantages:

- false alarms
- environmental conditions highly variable in NOPAC
- detect specific events (ash cloud or thermal anomaly)

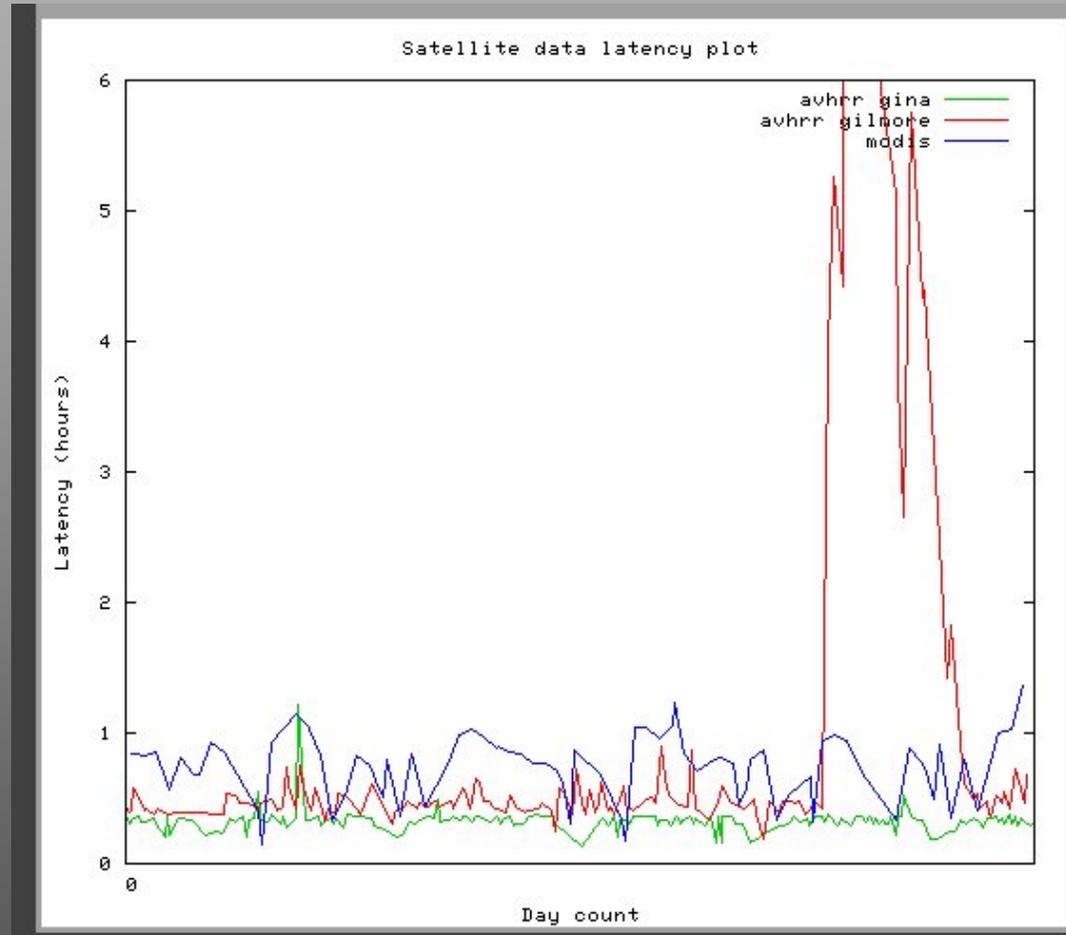
# Automated Assessment of Data Coverage

Alaska Volcano Observatory Pass Report		
start date	<input type="text" value="2006/5/4"/> (?)	70 passes <a href="#">show passes</a>
end date	<input type="text" value="2006/5/4"/> (?)	
time zone	<input type="radio"/> AK / <input type="radio"/> UTC	

image	info	subsector coverage
	<p>n14.06124.2357</p> <p>start of acquisition: 2006-05-04 23:57:00 UTC</p> <p>entry into AVO system: 2006-05-05 00:16:05 UTC</p>	no subsector coverage
	<p>n17.06124.2317</p> <p>start of acquisition: 2006-05-04 23:17:00 UTC</p> <p>entry into AVO system: 2006-05-05 08:38:07 UTC</p>	subsector coverage: <input type="text"/>
	<p>t1.06124.2313</p> <p>start of acquisition: 2006-05-04 23:13:00 UTC</p> <p>entry into AVO system: 2006-05-05 00:09:40 UTC</p>	subsector coverage: <input type="text"/>

# Assessment of Satellite Data Reception

Alaska Volcano Observatory Satellite Latency Grapher	
Start date	(?) 2006/5/1
End date	(?) 2006/5/6
Satellite Types	<input checked="" type="checkbox"/> AVHRR (GINA) / <input checked="" type="checkbox"/> AVHRR (Gilmore) <input checked="" type="checkbox"/> MODIS <input type="checkbox"/> GOES (GINA) / <input type="checkbox"/> GOES (Navy)
Axis label	days since data start
<input type="button" value="display"/>	



# Monitoring Database: Summary/Conclusions

1. **Developed:** response to data and information volume.
  2. **Operational and used by AVO.**
  3. **Information is archived and searchable.**
  4. **Reports automatically generated within seconds.**
  5. **Consistent and complete reporting.**
  6. **Faster and ensures critical information reported.**
  7. **Transported to other monitoring facilities.**
  8. **Applicable to other environmental assessment or monitoring systems.**
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