

Monitoring volcanic activity with satellite remote sensing to reduce aviation hazard and mitigate the risk: application to the North Pacific



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Operational System

Satellite data collected in real-time

Make use of Geo- and Polar data

Data center shows:
Data for a 24 hour period

Users carrying out report

Thermal alerts

Triggered ASTER requests

Ash alerts

Manual observations

AM/PM reports are made of observations for use by Alaska Volcano Observatory

AM/PM report

Observers analyze satellite data for ground-based thermal signals and ash clouds and plumes

Record cloud cover for alert volcanoes and all sectors
No activity recorded+cloudy = clouds could obscure activity
No activity recorded+clear = satellite data shows no activity

Record thermal signals, ash clouds/plumes

Use observation database tool to complete report

System will automatically send report out

Weekly report

Summarises activity from past week

Shows AM/PM reports with thermal signals (T) and ash clouds and plumes (P)

Emphasizes all volcanoes where observations made

Observer can select the relevant T or P and jump to the 40 x 40 zoomed in region around the volcano for that reported data set

Quarterly report

3 months of observations summarized by volcano and by day

Provides overview of volcanic activity for the North Pacific

Stored from 2005 - 2012 for each 3 month period (Jan-Mar, Apr-Jun, Jul-Sep and Oct - Dec)

Web Tools

Geophysical Institute - University of Alaska Fairbanks

- Observation Database**: Enter your Satellite Observations Here
- Image Flipper**: Interactive Animations of Current AVHRR, MODIS & GOES Satellite Data
- AVO RS Wiki**: Your Gateway to Documentation, News & Updates
- Puff Monitoring Tools**: Visualize Graphical Puff Output
- Webcam & Radar Links**: Links to AVO Webcam and Radar
- Observation Data Query**: Query Satellite Report Observation Data
- Weekly Report**: RSS Report for AVO 40 Weekly Meeting
- Quarterly Report**: RSS Report for AVO Quarterly Publication
- Volcano Locations**: Maps of all sectors showing names and locations of all volcanoes
- Data Center**: Past and Future 48 hours @ AVO RS
- 40x40 Hotspot Viewer**: Interactive Animations of Current AVHRR, MODIS & GOES Satellite Results
- Hotspot Report**: Query Current 40x40 Results
- Airfo Data Query**: Query Airfo Data
- Pass Report**: Query Available Satellite Passes
- Satellite Latency Grapher**: Query and Plot Latencies
- "Ash Band" Statistics**: Composite (SPAR Windows) Band Baselines
- AVHRR Ash Composites**: AVHRR Ash Composites for Sectors with Volcanoes at Elevated Color Codes
- OMI SO₂ Images**: Latest OMI SO₂ Data for Alaska, Kamchatka and Northern

Integration (webcam, TIR, seismic/air waves and ash modeling)

Webcam - 22:30 UTC

Satellite - 23:43 UTC (now detached)

Nikolski broadband seismic station

Both a seismic and a ground-coupled air wave were recorded. Air wave arriving about 200 s after the seismic wave. The seismic wave gives an origin time of about 22:03:30 UTC.

VATD model - says 7 km ASL (used seismic/infrasound for start time)

Hard to detect June 19, 2012
Did not trigger ash alert systems
Low contiguous number of pixels
Ash signal < 1 KT
Plume is approx 20 km

Thermal alerting system for All North Pacific volcanoes

Mid- and thermal infrared data used in real-time from MODIS, AVHRR, GOES and MTSAT

Examine precursory activity, type of ground activity, sub-pixel temperatures

Automated data analysis and alert system

Okmok II algorithm

Satellite data collected at UAF

Processed locally

Multiple levels of data analysis

Uses both MIR and TIR data

Applied to AVHRR and MODIS data

Assessment for noise

Based on spatial and temporal comparisons

Sends out thermal alerts by SMS and email

Determination if ASTER urgent request required

Archives into a database for post event analysis

Detection of volcanic ash clouds and plumes

Alert system analysis of brightness temperature difference (BTD) data

Emails and text messages sent based on BTD signals.

Can detect large volcanic events (Kasatochi 2008), small scale clouds (Cleveland 2012)

Features such as temperature inversion and re-suspension of ash can be seen as new volcanic event

Korovin Sector n15.08221,1641 - 08 Aug 2008 16:41 UTC Channel 4-5 (brightness temperature difference)

Future

Access to GOES-R and NPP level data

Many more spectral channels (GOES-R and NPP - 16 in VIS - IR)

Polar spatial resolution ~ 0.7 km, (few times a day currently)

Geo- temporal resolution of 15 mins

Thermal signals - Alaid Volcano November 8, 2012

Thermal alert was sent by email
MIR AVHRR channel = 66 C (2 saturated pixels)
Fresh lava flowing at the summit based on two saturated pixels

ASTER triggered acquisition from MIR signals

Kizimen Volcano
Data collected on November 6, 2012
Compared to AVHRR imagery from same date
ASTER data allows analysis of each feature
ASTER IR can detect smaller scale thermal signals
Can perform sub-pixel analysis of AVHRR data

AVHRR MIR signal
Max Temp = 41 C

ASTER IR signal
Max Temp = 318.3 K or 45.15 C
Summit crater signal = 3510 m²
Flow length = 2 - 3 km

Ash Signal October 6, 2012

Triggered ash alert system
Email and text alert sent

Ash signal = 10.5 KT
Plume is approx 3000 km²

Temperature Inversion April 23, 2008

Occurs under clear conditions from strong surface inversions in both the temperature and moisture signal

Effect of the temperature inversion is to lift the peak of the radiance contribution function so that the channel effectively receives more radiation from the layers above the surface

Differencing the two thermal infrared brightness temperature gives a false positive ash signal

Re-suspension of ash October 30, 2012

Occurs in Fall before snowfall is deep enough to hold the ash down. This effect is increased due to local instabilities from surface winds

Link satellite retrievals to volcanic ash model simulations

Satellite ash masses in real time within defined sectors

Generate ash model simulations to fit AVO sectors

Use satellite data to update ash simulations in real-time

Puff Volcanic Ash Transport and Dispersion model

Black regions as defined from satellite

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