Monitoring Volcano Threats from Space

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Abstract

Volcanic Hazards and Multi-Resolution Satellite Monitoring

Volcanoes pose significant local and regional threats during periods of intense activity. In addition to the local ground hazards, ash and sulphur dioxide gas clouds present hazards to aviation over a broad region. The accuracy of North Pacific volcanic activity assessments by the Alaska Volcano Observatory (AVO) has been improved through the use of higher resolution Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Earth Observing System (EOS) satellite imagery, following initial event detection using lower resolution Geostationary Operational Environmental Satellite (GOES), Advanced Very High Resolution Radiometer (AVHRR), and Moderate Resolution Imaging Spectroradiometer (MODIS) data.

North Pacific Aviation Vulnerability

Aqua MODIS: Augustine Volcano

Use of ASTER Data for Volcano Status Assessment

Volcano-specific thermal anomalies automatically detected in AVHRR and MODIS, and logged into an AVO database, trigger ASTER tasking requests. Custom tools were developed to assist in confirming initial detections, predicting satellite data observation opportunities, submitting and controlling emergency tasking requests, enabling rapid initial data assessments, and for distributing products. Acquired satellite data are promptly processed and distributed by the NASA Land Processes Distributed Active Archive Center (LP DAAC) at the U. S. Geological Survey (USGS) Center for Earth Resources Observation and Science (EROS). ASTER expedited data are typically available for study within six hours of collection. Data are retrieved and analyzed by AVO, and the resulting information is used as the basis for volcano status alerts sent to many organizations.

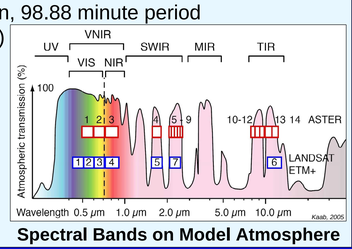
The ASTER Mission

The ASTER instrument was launched in 1999 on the Terra spacecraft, and is successfully conducting a global mapping mission. In addition to scheduled acquisitions on behalf of AVO, the ASTER instrument is also tasked to rapidly acquire Earth images for a wide variety of emergency response activities.

ASTER Data Characteristics

The ASTER instrument offers 14 spectral bands at wavelengths spanning the Visible and Near Infrared (VNIR), Shortwave Infrared (SWIR), and Thermal Infrared (TIR) regions. Both nadir and aft-viewing VNIR telescopes are employed, enabling the generation of digital elevation models. The data are suitable for a wide variety of Earth land surface studies.

Orbit: 705 km, sun-synchronous, 98.2 degree inclination, 98.88 minute period
Equatorial crossing time: 10:30 AM (descending orbit)
Tasking: Scheduled observations, 8% duty cycle
Revisit time: 16-days, less with off-nadir pointing
Scene area: Approximately 60 x 60 km
Ground resolution: 15m VNIR, 30m SWIR, 90m TIR
Data format: Hierarchical Data Format (HDF)-EOS
File size, Level 1B: 118 MB
Data source: LP DAAC http://LPDAAC.usgs.gov
GDS http://imsweb.aster.ersdac.or.jp/

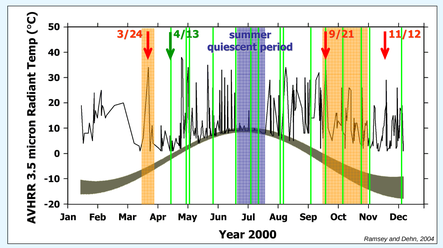


Spectral Bands on Model Atmosphere

Analysis Techniques and Tool Development Enable Rapid Volcano Status Updates

Detect Anomalous Event

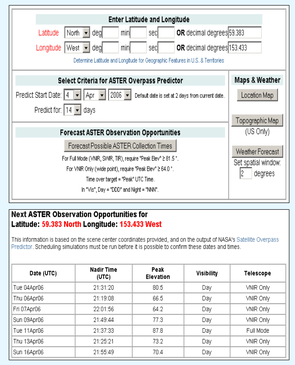
Lower resolution AVHRR, GOES, and MODIS data are used to identify new activity. Volcano-specific temperature thresholds developed at AVO are used to determine the significance of observed temperatures. AVO sends ASTER scheduling requests to LP DAAC to obtain more detailed information for further study.



Bezymianny data plotted with multi-year non-volcanic background and averaged temperature ranges (gray band)

Determine Overpass Opportunities

The ASTER Overpass Predictor developed by LP DAAC informs AVO when an orbit will enable observation of a specified target.



Task ASTER Instrument

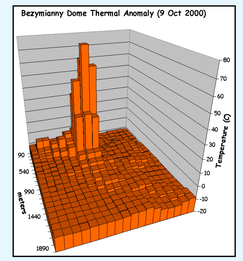
LP DAAC staff coordinate with the ASTER team at the Jet Propulsion Lab (JPL) to schedule observations. JPL staff work with ASTER associates in Japan to uplink the observation schedule to the spacecraft. LP DAAC built the ASTER Emergency Scheduling Interface and Control System for team use.

Acquire, Process, and Deliver Data

Data are downloaded from Terra, and processed to Level 0 at the Earth Observing System (EOS) Data and Operations System (EDOS). LP DAAC processes data to Level 1, and distributes imagery to AVO via File Transfer Protocol. LP DAAC developed and makes available an interface for rapid assessment and retrieval of these emergency data sets.

Analyze Data and Publish Alert

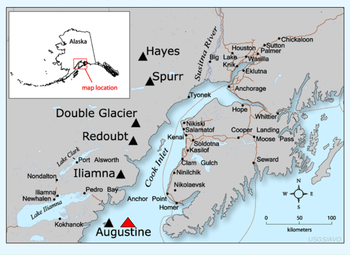
Staff at AVO analyze ASTER Level 1 data, compare ASTER observations with other available real-time satellite and ground-based data, determine the current state of the volcano, and if necessary issue an updated status report to Federal, state, and local agencies.



Application Example: Augustine Volcano, Alaska

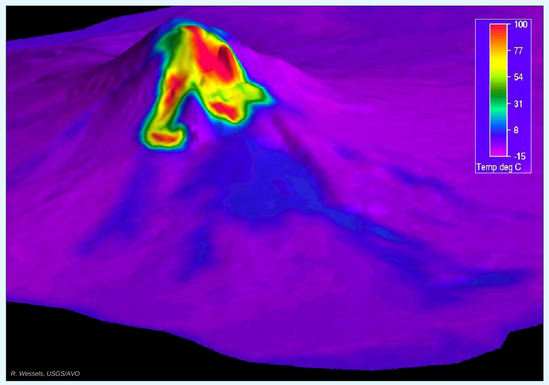
Define Plume Extent and Cloud-top Topography

The above image is a compilation produced using an ASTER scene, an ASTER digital elevation model, a Landsat 7 scene, and Shuttle Radar Topography Mission elevation data.



Location Map

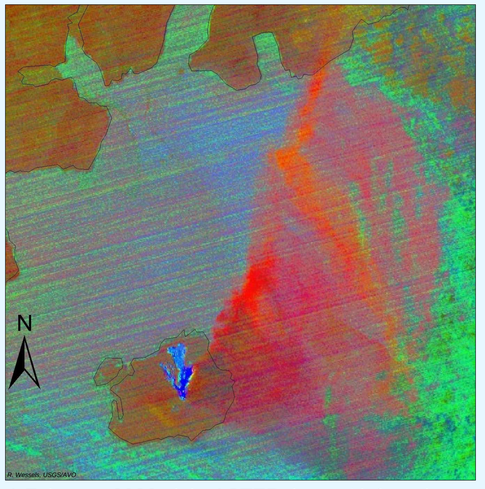
Identify Surface Temperature Conditions



13 March 2006 ASTER night 90 m thermal infrared data draped on a February 2000 SRTM digital elevation model. Cooling of the deposits from late January is evident, yet these are still warmer than the background temperature. The 100º C upper temperature limit is the highest ASTER TIR can measure. The 30 m SWIR data provided 460º C brightness temperature values.

Updated Augustine Volcano status reports based on current imagery provided accurate and timely information to international organizations.

Map Pyroclastic Flows, Ash and Gas Plumes



1 February 2006 night ASTER thermal infrared (TIR) data showing hot pyroclastic flow deposits on the north flank of Augustine Volcano. The image also shows a broad ash and sulphur dioxide plume as an orange-red feature to the east and northeast.

References Kaab, A. (2005): Remote sensing of mountain glaciers and permafrost creep, Physical Geography Series, Zurich, 48, 266 pages, ISBN 3 85543 244 9. Ramsey and Dehn, 2004, Journal of Volcanology and Geothermal Research, 135, p. 127-147.

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