THE VOLCANIC ERUPTIONS OF KAMCHATKA: ONE DECADE OF NASA SATELLITE OBSERVATIONS

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For the past eleven years, the joint US-Japanese Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument has been acquiring image-based data of volcanic eruptions in the Northern Pacific region. There have been more ASTER observations of Kamchatka volcanoes than any other location on the globe. The ASTER sensor has three distinct wavelength regions (visible/near infrared (VNIR), short wave infrared (SWIR) and thermal infrared (TIR)) and three spatial resolutions (15, 30 and 90 m/pixel). The data have proven extremely valuable for volcanological studies due the broad wavelength range, high spatial resolution, thermal infrared observations at night, and the ability to create digital elevation models (DEMs). At higher latitudes, the temporal resolution improves from the nominal 16 day repeat time to better than 7 days, which can then be further improved with off-nadir pointing and novel approaches such as integration with the data from other satellite sensors.

Early ASTER observations of the numerous eruptions in Kamchatka spurred interest in using the sensor for volcano monitoring in the north Pacific. These data gave rise to a now seven year long program of rapid response scheduling and imaging of volcanic activity throughout the Aleutian, Kamchatka and Kurile arcs. This program was designed to automate the ability of the ASTER instrument for targeted observations and expedited processing. The urgent request protocol (URP) is one of the unique characteristics of ASTER, which provides a limited number of emergency observations, typically at a much-improved temporal resolution and quicker processing time. The system has been combined with the operational monitoring carried out by the Alaska Volcano Observatory (AVO), which relies on high temporal/low spatial resolution (4-6 hours/1.1-km) AVHRR data to detect thermal anomalies and plumes. The integrated ASTER URP program has resulted in a much improved observational frequency (e.g., daily over three day periods) and the data being made available within 2-4 hours after it is acquired.

Automated hot spot alarms from the AVHRR data (assuming the volcanic activity is strong enough to be detected) trigger ASTER acquisitions using the "rapid response" mode. Specifically for Kamchatka, the URP Program has resulted in more than 700 additional ASTER images of the most thermally-active volcanoes (e.g., Shiveluch, Kliuchevskoi, Karymsky Bezymianny and Kizimen). The program is now averaging one new ASTER image over the Kamchatka Peninsula approximately every three days, with 48% of the total archive focused on Shiveluch due to its long-lived persistent activity. These data have produced valuable quantitative information on the small-scale activity and larger eruptions.

Numerous eruptions have been observed in Kamchatka, which have displayed varying volcanic styles. The high spatial resolution and moderate spectral resolution (particularly of the ASTER TIR system) has been ideal for deriving the composition, vesicularity, and emplacement rates of active domes and flows. The entire ASTER archive was queried and two specific examples are presented here. Bezymianny is characterized by a summit lava dome and overlapping pyroclastic flow (PF) deposits to the southeast. Three explosive eruptions (24 December 2006, 11

May 2007, and 14 October 2007) generated pyroclastic flows dominated by juvenile material primarily due to column collapse. Following this, a gravitational lava dome collapse event generated block and ash flow on 5 November 2007. ASTER data acquired over this time period detected three periods of increased thermal activity that coincided with each eruption. For two of these periods, the thermal output increased significantly just prior to the eruption (Figure 1). These data provide information on an actively changing explosive volcanic system and specifically documents changes over recently-emplaced and cooling PF deposits.

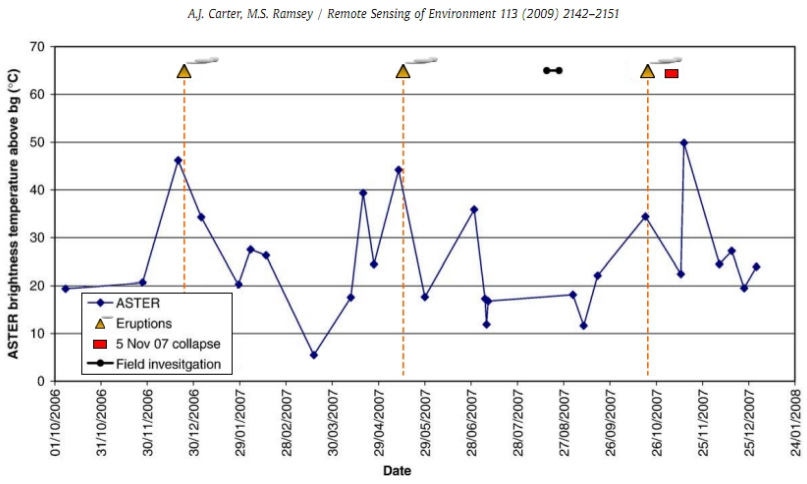

Figure 1. *ASTER TIR-derived pixel-integrated max brightness temperature over the Bezymianny lava dome from Oct. 2006 to Dec. 2007. Significantly elevated temperatures were noted around the times of the Dec. 2006 and May 2007 eruptions. However, only slightly-elevated temperatures were detected prior to the Oct. 2007 eruption, which may have been caused by thin clouds obscuring the dome. ASTER temperatures are accurate to within 2°C, which provides an error margin on the data.*

Shiveluch Volcano is one of the largest and most vigorous andesitic volcanoes in Kamchatka. The volcano has been in a long period of heightened activity during the years from 2004-2010. ASTER TIR data were collected during both day- and night-time satellite overpasses prior to and following the large eruption of 27 Feb 2005 and the dome growth that followed. During a field campaign six months later, the summit crater was overflown by helicopter and an actively-extruding silicic lava dome was imaged. The airborne and spaceborne TIR data were compared to long distance ground-based photography of the dome in order to calculate the extrusion rates. This highly active period at Shiveluch provided a unique base from which to extend previous models of silicic lava dome growth and subsequent collapse.

In summary, the ASTER rapid response program in Kamchatka and Alaska has resulted in hundreds of new ASTER scenes. The ongoing research/operational program is a collaboration between NASA, the USGS, AVO, IVS/KVERT, the University of Pittsburgh (UP) and the University of Alaska – Fairbanks (UAF) and has proven to be highly successful. This work has recently been funded by NASA for another three years. The focus on the North Pacific will continue and a new goal has been added to expand the system globally using detections from the MODIS sensors. The program should improve the frequency of ASTER data for active eruptions worldwide and provide a template for future sensors and sensor web integration.