



## Characterization of volcanic activity using observations of infrasound, volcanic emissions, and thermal imagery at Karymsky Volcano, Kamchatka, Russia

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Karymsky Volcano is one of the most active and dynamic volcanoes in Kamchatka, with activity ranging from vigorous degassing, frequent ash emissions, and apparent vent sealing, all punctuated by daily to weekly explosive magmatic eruptions. Recent studies have highlighted the strengths in using complementary infrasound measurements and remote volcanic emission measurements to characterize volcanic activity, with the potential to discriminate emission-type, approximate ash-cloud height, and estimate  $\text{SO}_2$  emission mass. Here we use coincident measurements of infrasound,  $\text{SO}_2$ , ash, and thermal radiation collected over a ten day period at Karymsky Volcano in August 2011 to characterize the observed activity and elucidate vent processes. The ultimate goal of this project is to enable different types of volcanic activity to be identified using only infrasound data, which would significantly improve our ability to continuously monitor remote volcanoes. Four types of activity were observed. Type 1 activity is characterized by discrete ash emissions occurring every 1 – 5 minutes that either jet or roil out of the vent, by plumes from 500 – 1500 m (above vent) altitudes, and by impulsive infrasonic onsets. Type 2 activity is characterized by periodic pulses of gas emission, little or no ash, low altitude (100 – 200 m) plumes, and strong audible jetting or roaring. Type 3 activity is characterized by sustained emissions of ash and gas, with multiple pulses lasting from ~1 – 3 minutes, and by plumes from 300 – 1500 m. Type 4 activity is characterized by periods of relatively long duration (~30 minutes to >1 hour) quiescence, no visible plume and weak  $\text{SO}_2$  emissions at or near the detection limit, followed by an explosive, magmatic eruption, producing ash-rich plumes to >2000 m, and centimeter to meter (or greater) sized pyroclastic bombs that roll down the flanks of the edifice. Eruption onset is accompanied by high-amplitude infrasound and occasionally visible shock-waves, indicating high vent overpressure. We observed the four different activity types using the following instruments: (1) infrasound was recorded using a 4 element array of NCPA digital microphones, (2)  $\text{SO}_2$  emissions were measured using both a scanning FLYSPEC ultraviolet spectrometer system and a Cyclops infrared camera, (3) broadband, 8.6, 10, and 11 micron filters were used with the infrared camera to allow detection and quantification of both  $\text{SO}_2$  and ash, and (4) a FLIR infrared camera was also used to record high temporal resolution thermal observations of the volcanic emissions and hot eruption deposits. During our field campaign we observed several hours of Type 1 – 3 activity, in addition to seven Type 4 events, all of which were detected infrasonically and several of which were observed by the various remote sensing instruments. Here we present our preliminary observations and attempt to characterize and understand the four types of activity observed at Karymsky Volcano.