# Ground-based analysis of volcanic ash plumes using a new multispectral thermal infrared camera approach (*PA43C-2196*)

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## Introduction

Volcanic plumes are complex mixtures of mineral, lithic and glass fragments of varying size, together with multiple gas species. Understanding the particle size, distribution and mass throughout a volcanic plume can allow us to model more accurately the eruption dynamics (Gudmunsson et al., 2012). However, determining the physical and mineralogical properties of a volcanic plume immediately after an eruption is a great challenge (Pergola et al., 2004). Using the thermal infrared (TIR) emissive properties of volcanic ash, a new method has been developed to determine the plume's particle size and petrology in spaceborne and ground-based TIR data. A multispectral adaptation of a thermal camera has been developed that simulates the TIR channels found on several current orbital instruments.

## Methods

- Data were collected during a field campaign to Guatemala between 16 Feb and 6 March 2015.
- Multispectral adaptation of a TIR camera (Ramsey and Harris, 2013; Figure 1).
- Data from small strombolian/vulcanian eruptions was collected at Fuego and Santiaguito (Figure 2).
- Data obtained approx. 6 km from the vent in both cases.
- Six filters used, covering TIR wavelengths 8.05, 8.6, 9.05, 10.07, 10.71 and 11.4 µm.
- Single images from each wavelength filter isolated, and then converted to emissivity.
- Emissivity spectra analyzed to determine if compositional and particle size data are extractable.
- The images were then processed using the spectral deconvolution method of Ramsey and Christiansen (1998).

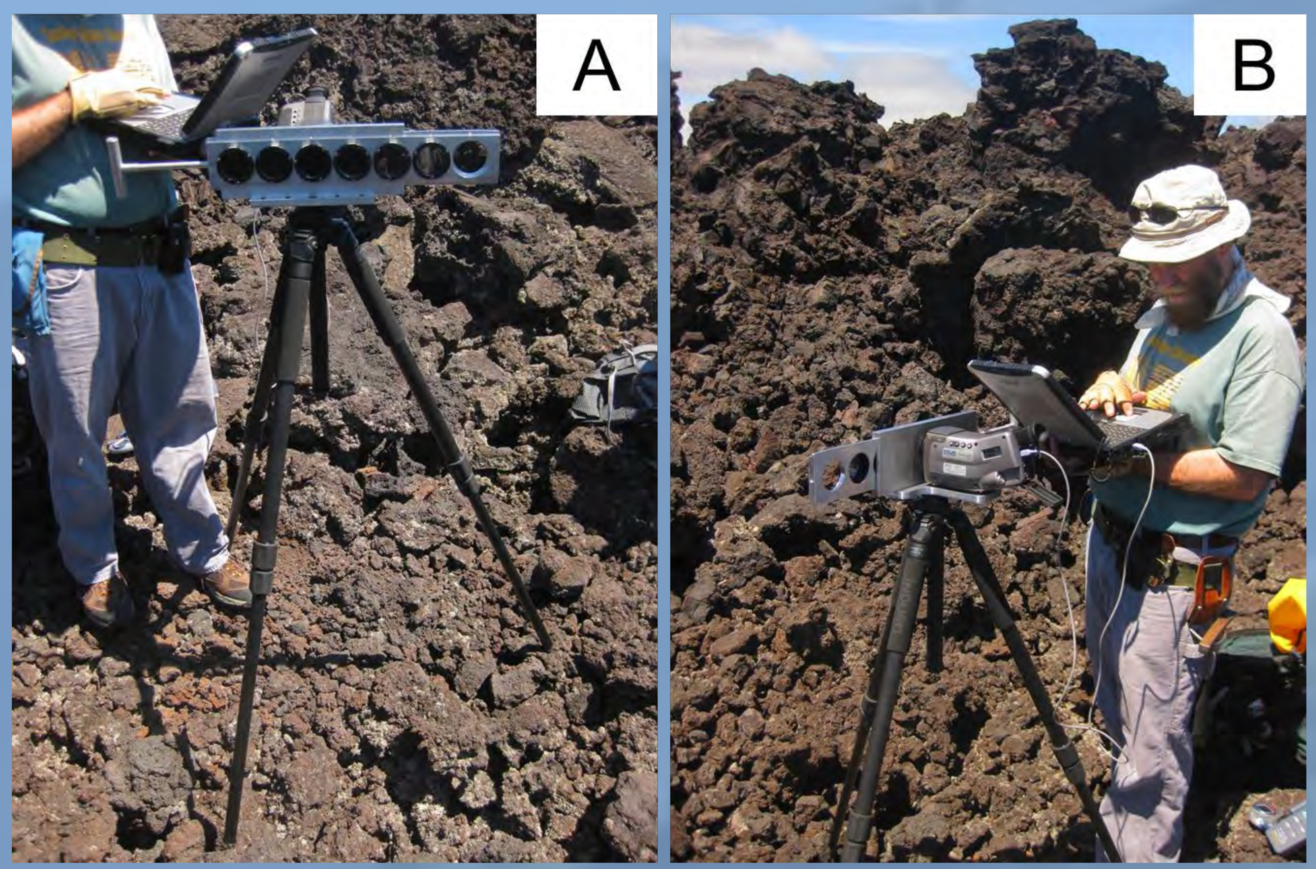


Figure 1 – The multispectral TIR camera being operated during fieldwork in Hawaii, 2014 (photos courtesy of Dr. R. Lee, SUNY Oswego). Panel A shows the front of the system, with the filters placed along the slider mechanism. The additional empty space allows broadband TIR temperature data to also be collected near coincidentally. In Panel B, the camera can be seen to sit flush to the back of the filter system to allow the slider to pass smoothly in front, but also to stop additional radiance from the area from being detected.

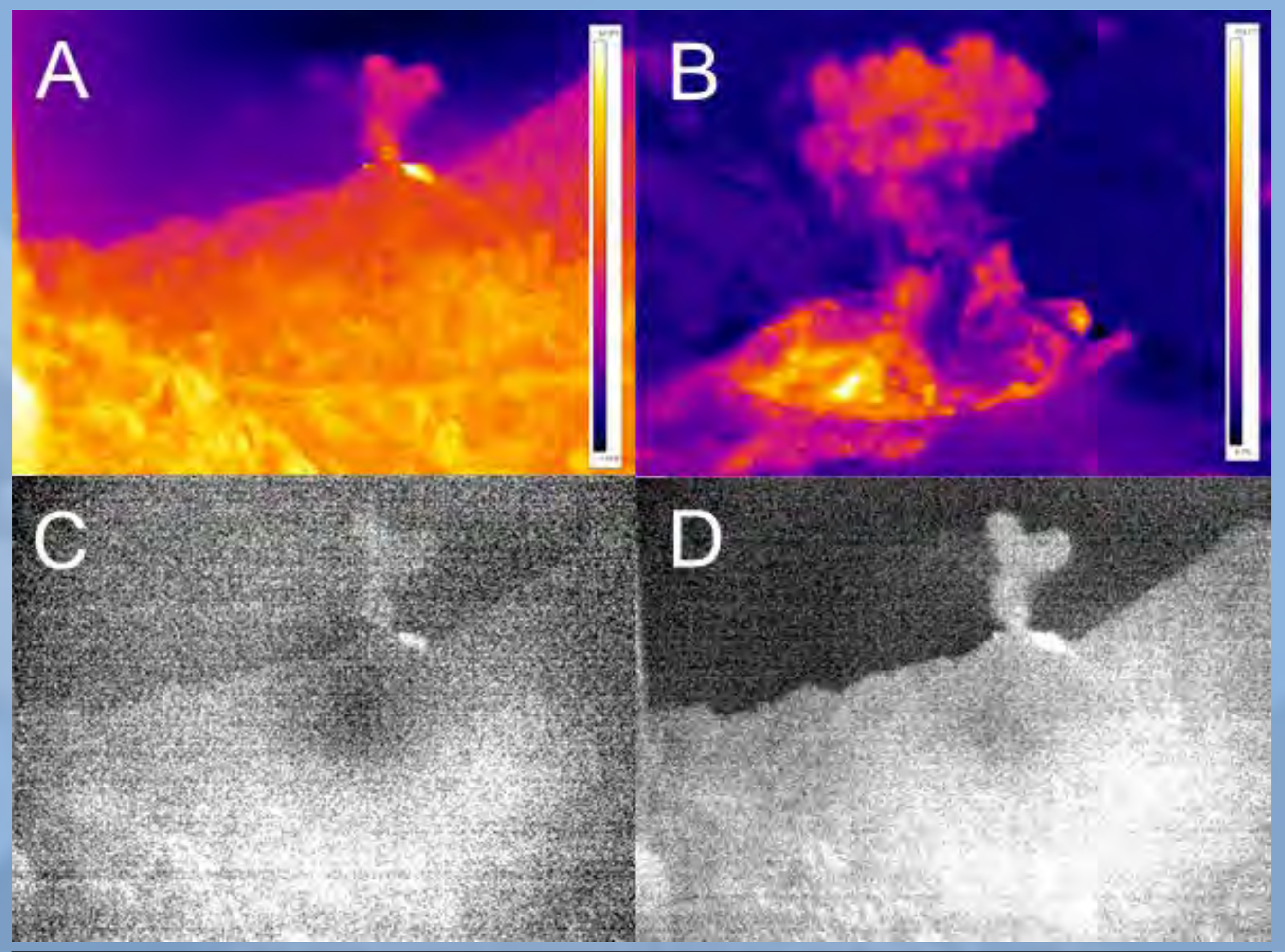


Figure 2 – A and B) Broadband temperature images of Santiaguito volcano, Guatemala taken on March 4th and 5th 2015 respectively. Santiaguito volcano is being studied due to the unique opportunity to view the eruption columns from multiple angles; C and D) Images of the eruption shown in A) for two filters centered at 8.05 and 8.6 µm, after being converted to radiance. The 8.6 µm filter (D) is useful as silicate ash and $SO_2$ have absorption features at this wavelength

## Results

- Data retrieved from these two volcanoes has shown the viability of this technique
- Spectral features that resemble those of silicate ash can be identified in images from both Fuego and Santiaguito volcanoes (Figure 3)
- Whilst atmospheric effects have already been corrected, water vapor and $SO_2$ within the plume need to be addressed so that the ash properties can be identified
- Spectral deconvolution results show that petrological data is extractable
- Basaltic andesite lab spectra provide a good fit for Fuego and Santiaguito, but the crushed high silica glass produced data that did not correlate as well with the plume and had large Root Mean Squared (RMS) errors (Figure 4)

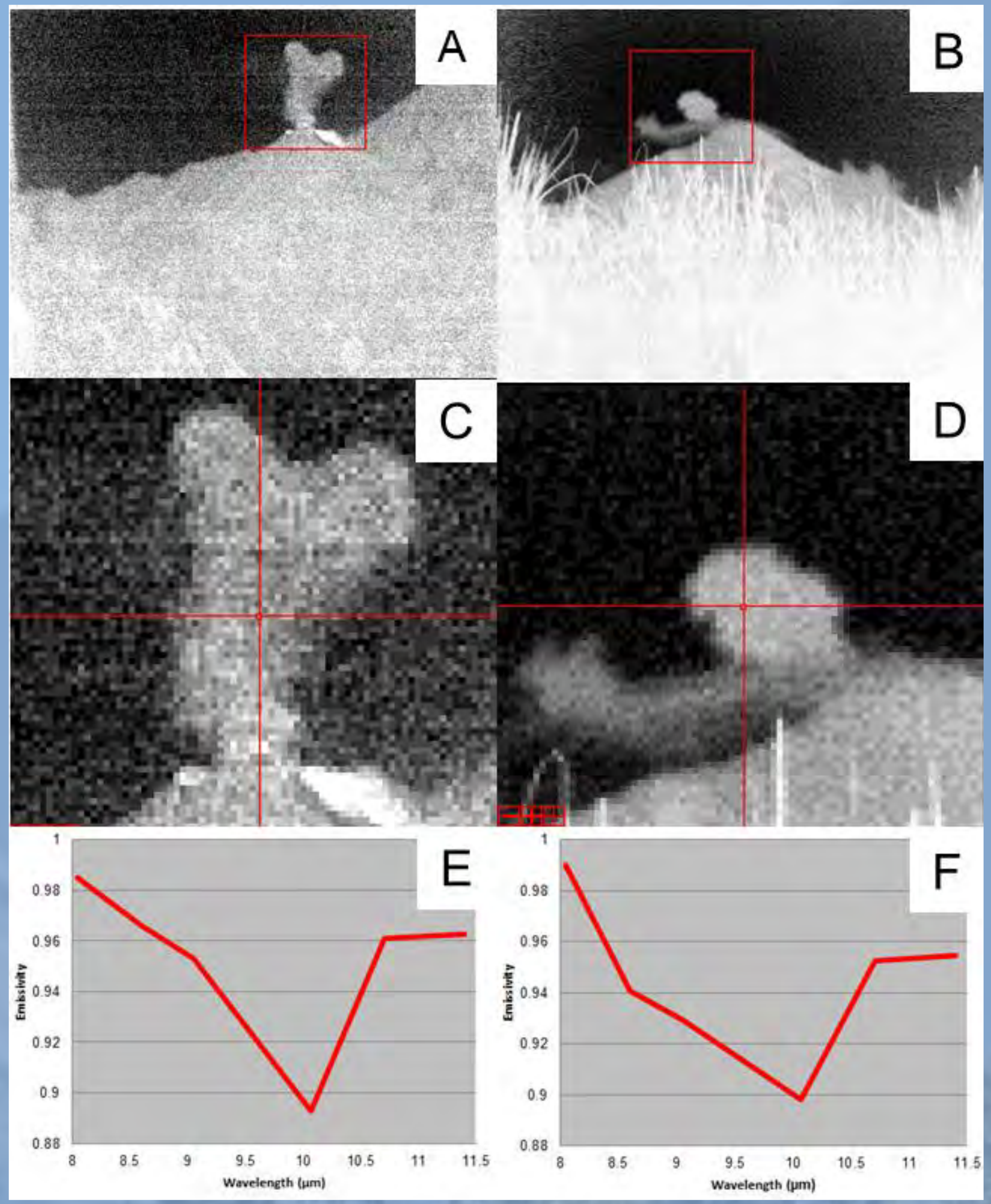


Figure 3 – Images taken from eruptions of the Santiaguito (A) and Fuego (B) volcanoes. The red box in these images indicate the areas shown in C and D. The red cross on each image shows the location of pixels, whose emissivity spectra are shown in in E and F. Note the distinct absorption feature at around 10.07 µm in both plots. This absorption is seen in pixels throughout this channel. Further testing and calibration is required to accurately quantify this error.

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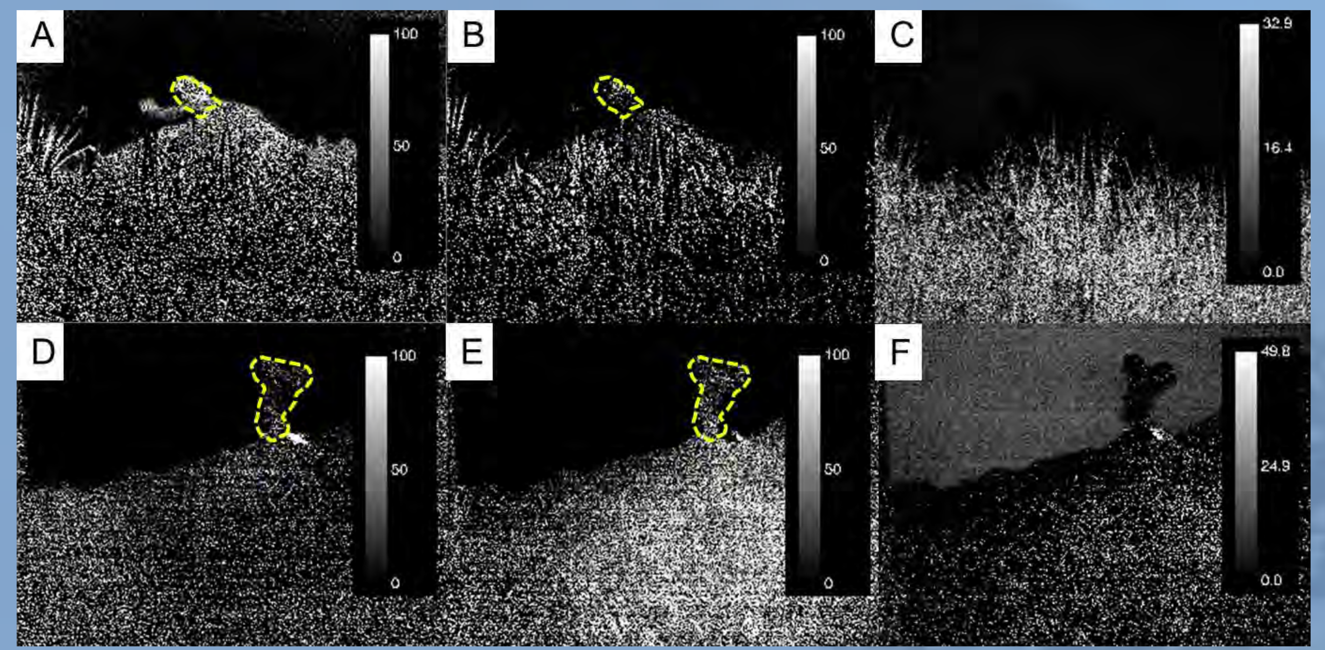


Figure 4 – Spectral deconvolution results for the eruption plumes from Fuego (Top row) and Santiaguito (bottom row). Both sets were processed using a basaltic andesite end member library. A) 5 µm end member result; B) 35 - 45 µm end member result. C) RMS errors. Note that the volcano itself displays low errors but the vegetation in the foreground is much higher. D) 5 µm end member result; E) 5 – 15 µm end member result; F) RMS error. Once again the plume and volcano flanks had low errors compared to the sky and vegetated foreground.

## Conclusions

This work is the first attempt to determine compositional and ash size remotely from the ground during eruptive activity. We expect continued improvement in the instrumentation and automation of the technique, which will be tested during future field campaigns. These results will be validated through collection of in situ ash collection and comparison to TIR data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). Application of this approach to the ASTER data also provides the ability to analyze small-scale plumes from any volcano around the globe.

### References

Gudmundsson M.T. et. al., 2012. Ash generation and distribution from the April-May 2010 eruption of Eyjafjallajökull, Iceland. Sci. Rep. doi:10.1038/srep00572

Pergola, N., Tramutoli, V., Marchese, F., Scaffidi, I., & Lacava, T., 2004., Improving volcanic ash cloud detection by a robust satellite technique. Rem. Sens. Environ., 90(1), 1-22.

Ramsey, M.S. and Christensen, P.R., 1998. Mineral abundance determination: Quantitative deconvolution of thermal emission spectra, J. Geophys. Res., 103, 577-596.

Ramsey, M. S., & Harris, A. J. 2013. Volcanology 2020: How will thermal remote sensing of volcanic surface activity evolve over the next decade?, J. Volc. Geo. Res., 249, 217-233.