AVAL – The ASTER Volcanic Ash Library (*V11C-2810*)

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Introduction

Ash-rich volcanic eruptions are one of the most widespread geologic hazards, with effects ranging from respiratory problems for local communities, to the well-documented hazards to aircraft. The severity of the hazard is a function of the particle size and composition of the ash. Studies have focused primarily on determining the location and approximate density of volcanic ash clouds, using a suite of high temporal but low spatial resolution satellite sensors. However, what is missing is high spatial resolution data particularly for that portion that is closest to the vent. By using an appropriate TIR spectral end-member library, and high resolution data from the Advanced Spacebourne Thermal Emission and Reflectance Radiometer (ASTER), it is possible to map the composition and particle size of volcanic ash using their unique emission spectra. Here, we present AVAL – the first volcanic ash end member library.

Why use ASTER?

- Multispectral TIR capability with 90 m spatial resolution
- Capable of observing the proximal portion of plume in greater detail, therefore able to accurately map particle size variations
- Nominal temporal resolution of 16 days at equator, 5 at higher latitudes; can be increased using the ASTER Urgent Request Protocol (URP; Ramsey, 2015)
- Operational for 16 with a vast back catalog of eruption data available

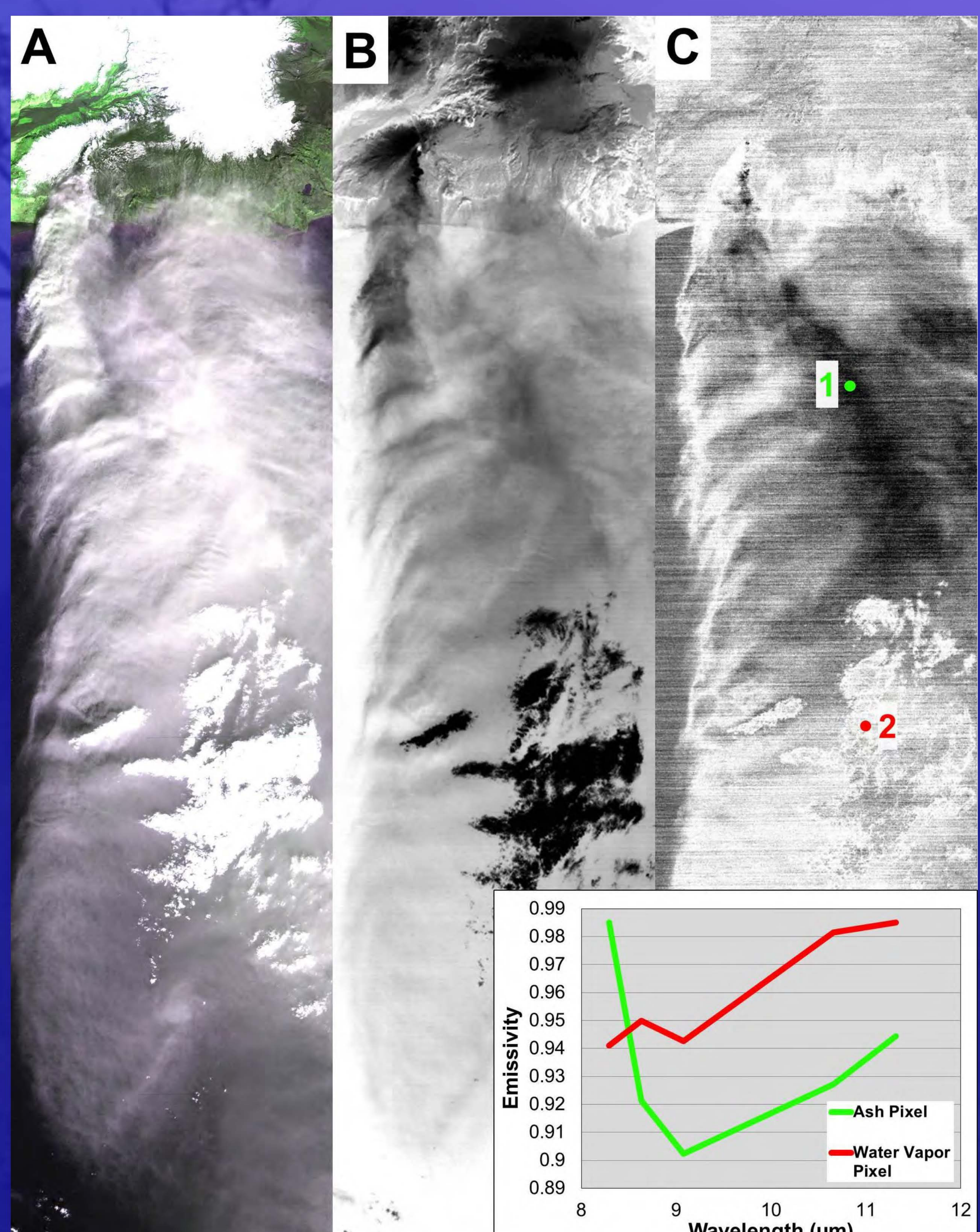

Figure 1. Mosaic of 4 ASTER scenes obtained during the eruption of Eyjafjallajökull on 17 April 2010. (A) False color VNIR image; (B) TIR radiance (Band 13) and (C) TIR Band 11 emissivity image. Points 1 and 2 refer to pixel spectra that are shown in the plot (bottom right). Pixel 1 has a spectrum indicative of volcanic ash, whilst pixel 2 was taken from a meteorological cloud. Their distinctiveness demonstrates the potential for emissivity as a mapping tool.

Ash Preparation

- Ash samples collected from 4 field sites: Fuego and Santiaguito volcanoes (Guatemala), Soufrière Hills Volcano (SHV; Montserrat), Sakurajima (Japan)
- Crushed obsidian from Mono-Inyo domes, California, used as high SiO_2 analogue end member
- First fractions sieved to > 150 µm, 63 – 150 µm, 45 – 63 µm and < 63 µm
- The < 45 µm fraction then subdivided into 4 smaller fractions using a Microorifice Uniform Deposit Impactor (MOUDI) (Marple et al., 1991)
- The process allowed separation into 18 – 45 µm, 10 – 18 µm, 1 – 10 µm and < 1 µm fractions

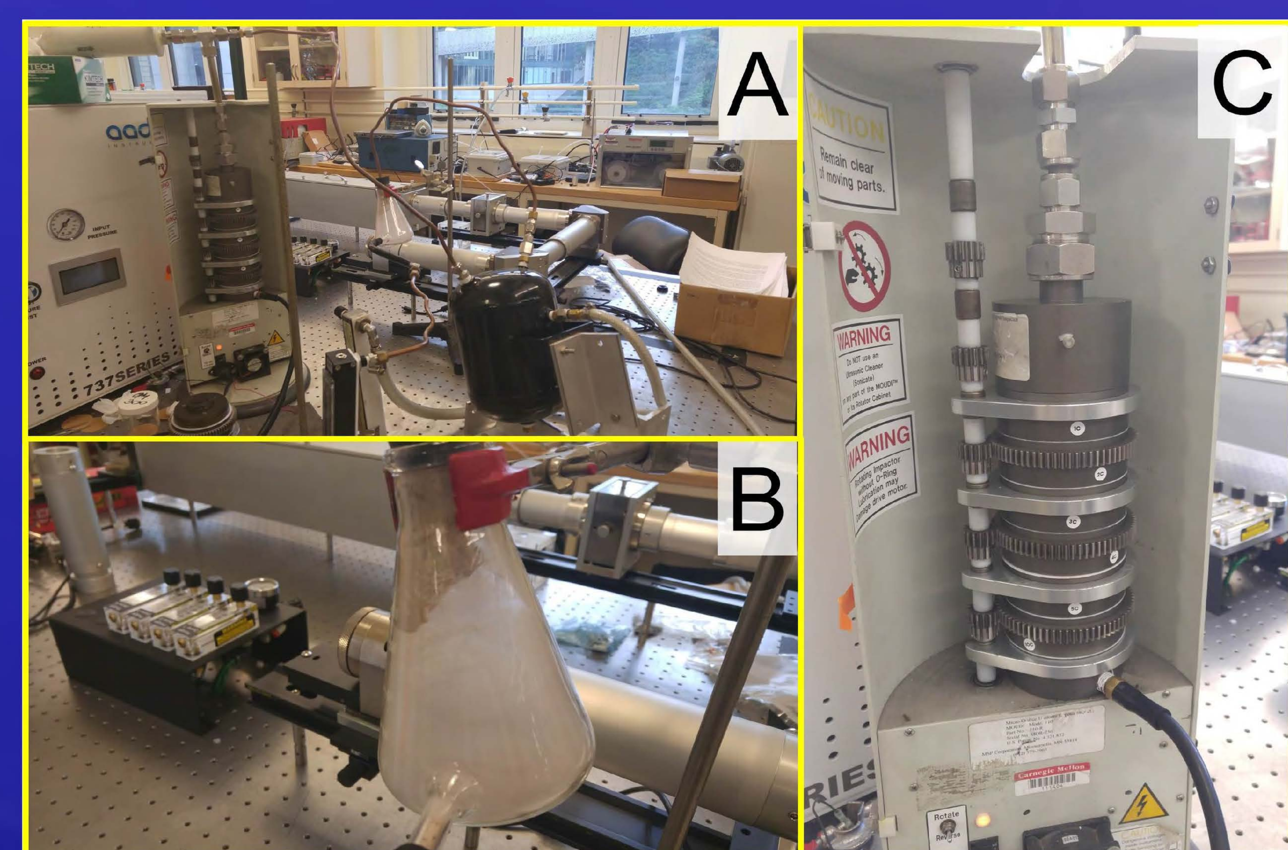

Figure 2. (A) The MOUDI laboratory equipment at the Air Quality Laboratory, Carnegie Mellon University. This is used to separate the finest fractions of volcanic ash. Ash is placed in the beaker shown in (B) with compressed air flushed through to suspend the ash. Once suspended, the ash is sent through to the MOUDI plates shown in (C). If the ash particle is small enough it will be transported through to the next stage, however if the particle diameter is too large it will impact onto the foil substrate instead.

Spectra Collection

- Fractions placed in an 80 ºC drying oven
- Sample emission acquired using a Nicolet Nexus 670 FTIR Spectrometer following methods outlined by Ruff et al. (1997)
- Laboratory spectra are reduced to ASTER 5 point multispectral resolution
- Library can be used with appropriate end member model

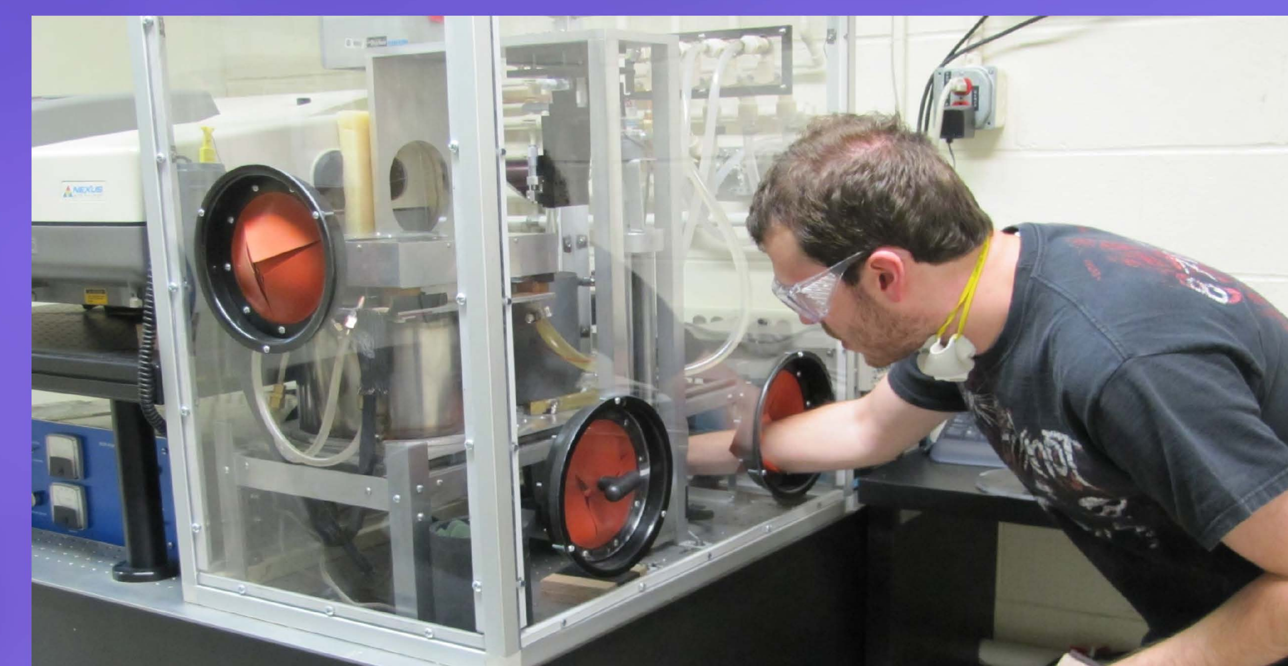

Figure 3. TIR emission laboratory at the University of Pittsburgh showing sample placement prior to spectral acquisition.

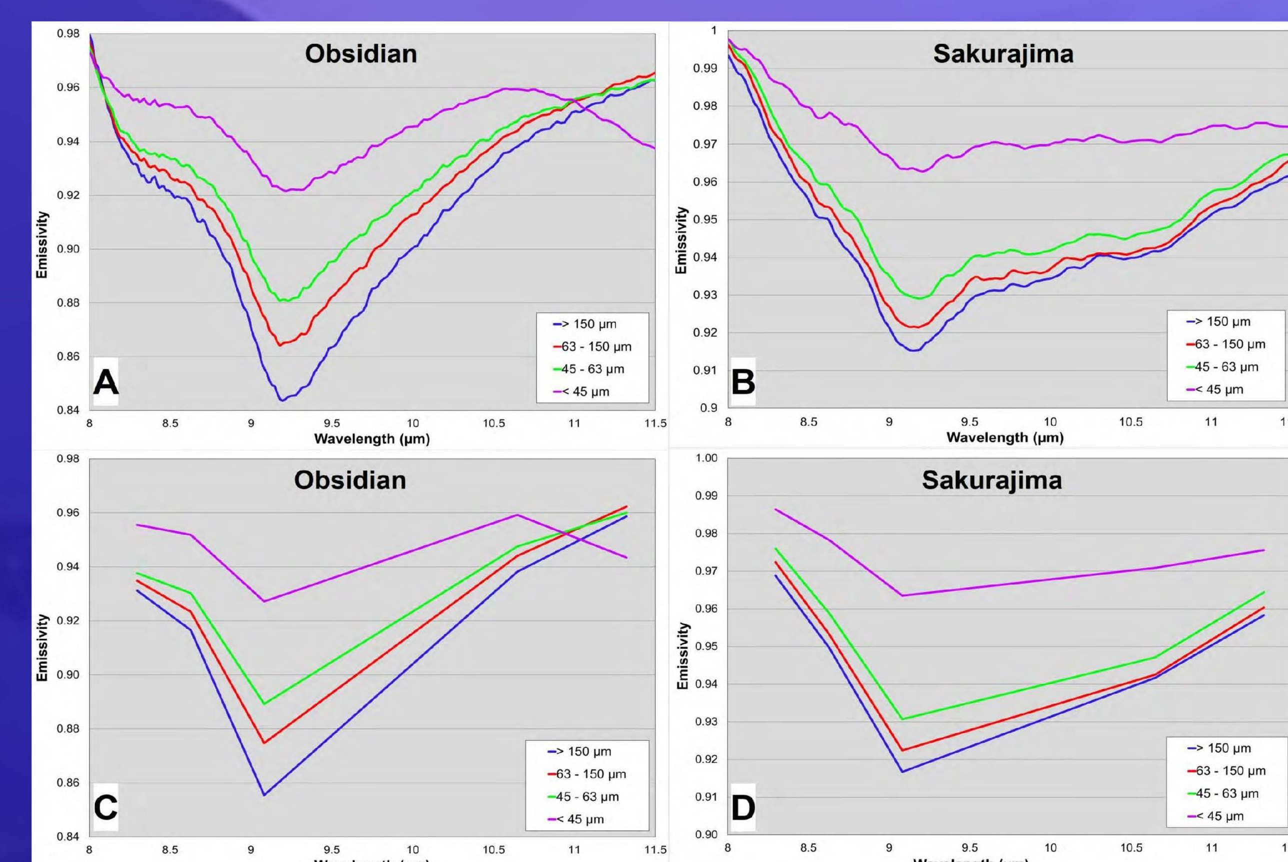

Figure 4. Laboratory (A and B) vs ASTER (C and D) spectra obtained from two samples. Note, even with the degradation to just five points, the main spectral features are still visible and able to be distinguished

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Spectral Library

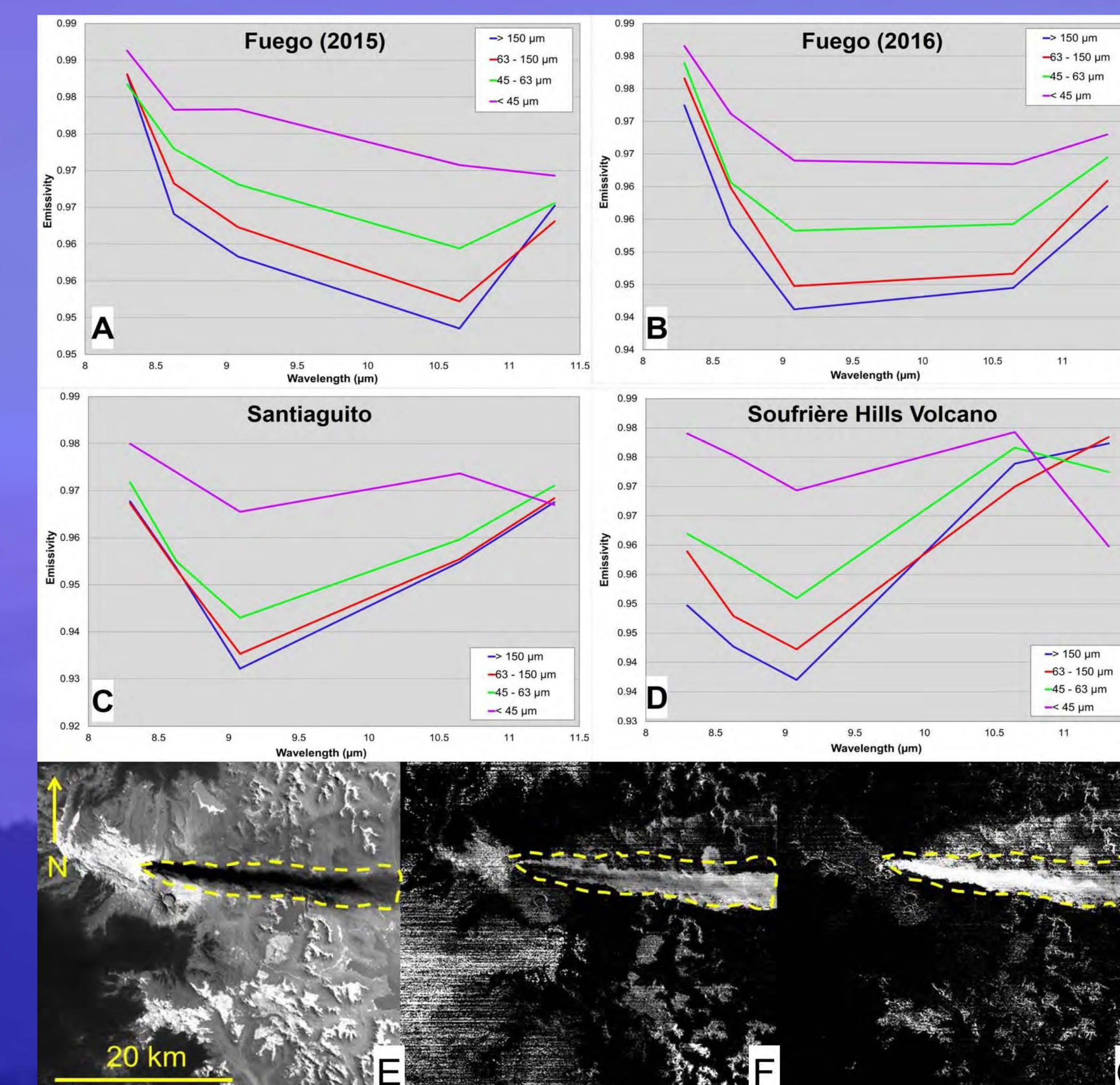

Figure 5. A – D; AVAL library spectra shown at ASTER TIR resolution. Differences in composition/petrology are reflected in the spectral morphology, whereas the overall reduction in contrast denotes the effect of smaller particle sizes. Panels E – G are results generated using the spectral deconvolution method of Ramsey and Christensen (1998) on a 11 June 2011 ASTER image from the Puyehue-Cordón Caulle volcano, Chile. E is an AST_09 Band 14 radiance image, F and G are the results using the obsidian end member, for 45 – 63 and < 45 µm.

Future Work

- Continually expanding library with relatively fresh (erupted within 1 year) unweathered sample of ash fall
- Basaltic samples still needed in addition to a larger suite of the more silicic compositions (e.g., dacite and rhyolite)
- AVAL will be made available online for download once testing and expansion is complete