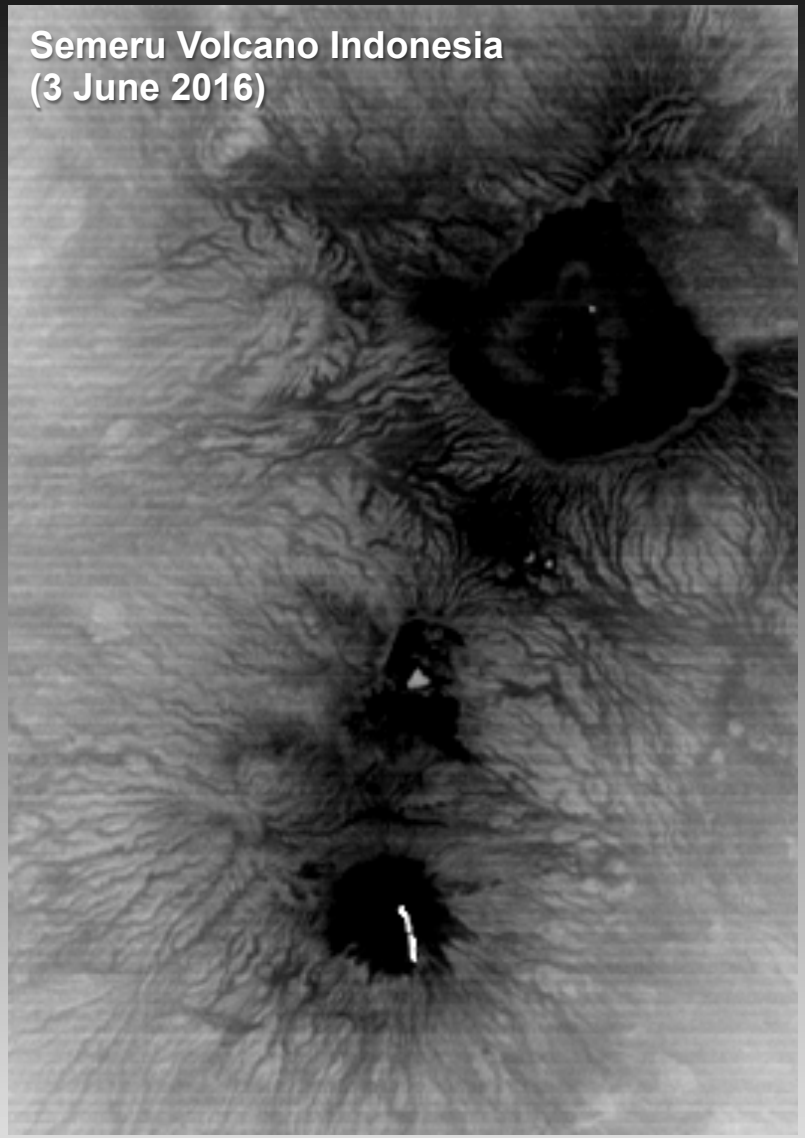
The HyspIRI volcano airborne campaign: Development of a new infrared camera for data acquisition and validation

Michael Ramsey & James Thompson

University of Pittsburgh, Department of Geology and Planetary Science, Pittsburgh, PA, USA



2016 HyspIRI Science and Applications Workshop
Pasadena, CA (18-20 October 2016)

Quantifying active volcanic processes and mitigating their hazards with HyspIRI data

Michael Ramsey, University of Pittsburgh

Objectives:

- Task 1:Quantify the magnitude of temperature-dependent emissivity change for active basaltic surfaces using in situ field and laboratory IR data *(fundamental science)*
- Task 2: Determine the accuracy of high-temperature emissivity extraction at potential HyspIRI spatial resolutions and its impact on modeling of flow advance *(applied science)*

Requirements and Constraints

- Start Date Preference: Fall 2016 or Spring 2017
- Surface Elevation: 0 to ~ 4000 feet
- Weather Conditions: clear, no/low clouds
- Cloud Cover (Max): 10%
- Sun Angle Limits: not important
- Ground Condition: dry
- Satellite Overpass?: yes, *Terra* at ~ 11am/11pm LT
- Sea State/Tidal Cycle: n/a
- Additional requirements: coordination with field team and HVO staff

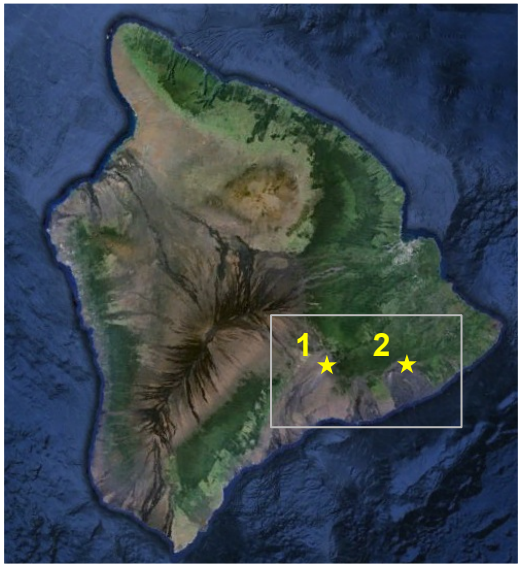
Approach

- The airborne data will be forward-modeled using a quantitative resampling methodology.
- During the overflights, ground-based multispectral TIR data will be acquired from a newly-developed instrument.
- The combined data will be used to validate a correction approach for thermally-mixed HyspIRI data using VSWIR & TIR data.
- Results will be input into flow modeling to better monitor and predict future volcanic hazardous phenomena.

Collaborators: Andy Harris *(UBP, France)*, Matt Watson *(UB, England)*, Matt Patrick *(HVO)*

Investigation Sites

- Locations: Big Island of Hawaii with specific targets centered on the active lava locations
  1. lava lake at Kilauea crater
  2. active flows in the East Rift Zone



Proposed Work

❖ Quantifying active volcanic processes and mitigating their hazards with HyspIRI data

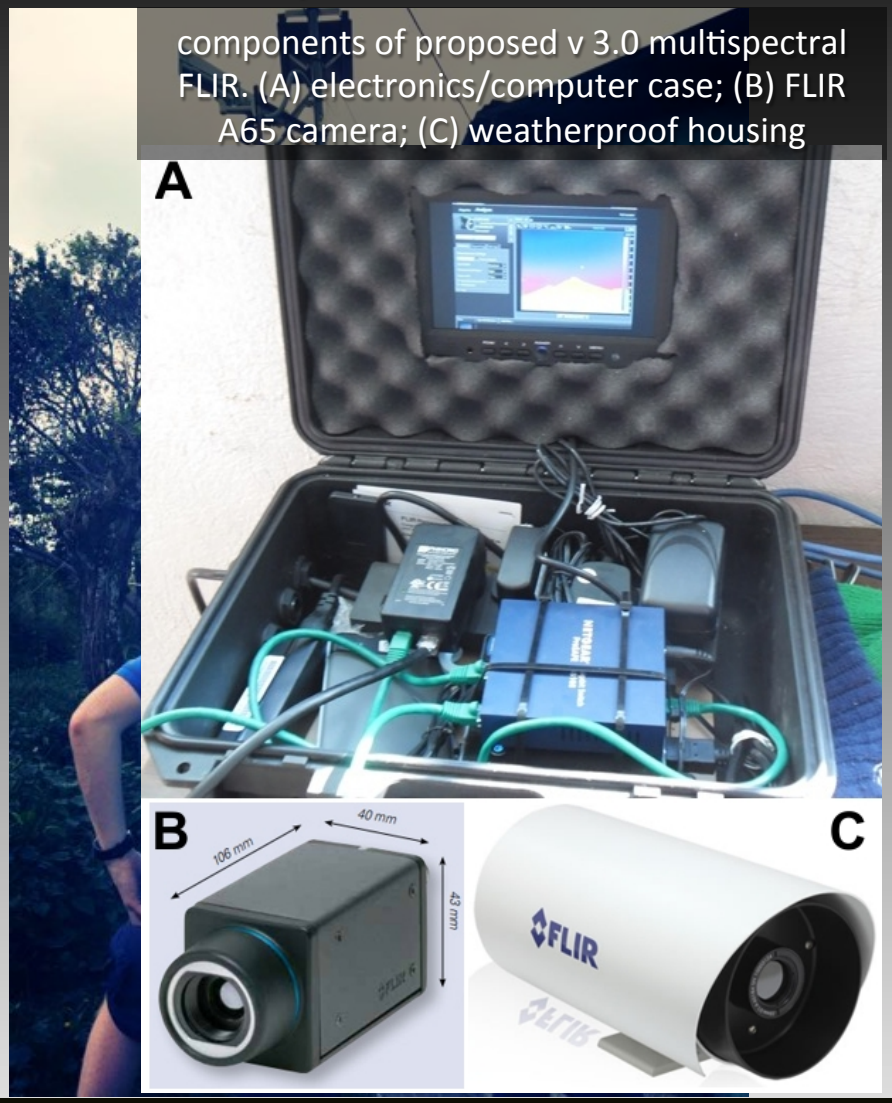
- proposed science questions:
  - how does the cooling and formation of a viscoelastic hot glassy surface affect the average emissivity of basaltic lava over time?
    - ➢ can these constituents be quantitatively extracted from future HyspIRI data of active flows to produce improved temperature and compositional estimates?
  - what are the ideal spatial resolution and band positions for the HyspIRI IR instrument to extract quantitative volcanological data?
  - can this approach in total be helpful for the prediction of lava flow advance over time through quantitative modeling of HyspIRI data?

HyspIRI: Proposed Work

❖ Proposed Tasks

- Task 1a: Development of a new miniature multispectral IR camera (v. 3.0)
  - concept based on an automated FLIR webcam deployed in Guatemala
  - v. 3.0: fully automated, easily field-deployable with long operational time
  - *progress:*
    - new graduate student onboard
    - all components purchased
    - assembly nearly complete

components of proposed v 3.0 multispectral FLIR. (A) electronics/computer case; (B) FLIR A65 camera; (C) weatherproof housing



Previous Prototype Developments

❖ Field Multispectral FLIR

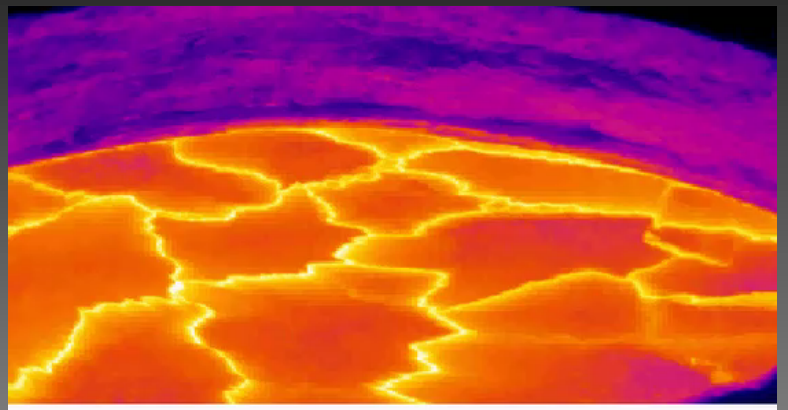
- originally adapted a FLIR camera to measure *in situ* emissivity
  - six wavelength filters fabricated to replicate ASTER, MODIS, MASTER and HyspIRI channels
    - ➢ acquired ≈ 3 frames/filter pass
    - ➢ slow process of post-processing
  - collection and post-processing now automated (v. 2.5)
    - ➢ allows for remote, autonomous deployment in a variety of conditions

deployment of v. 2.0 multispectral FLIR in Hawaii (2014)

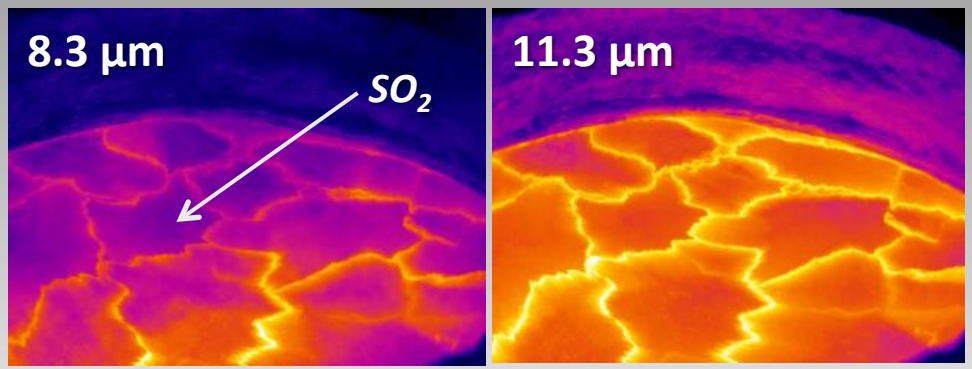
Previous Prototype Developments

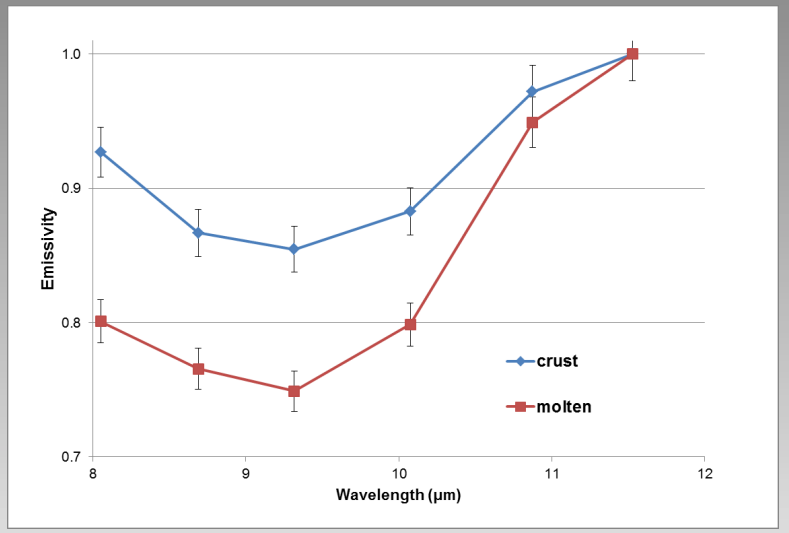
❖ Field Multispectral FLIR

- v. 2.0 tested at Halemaumau lava lake, Kilauea *(August, 2014)*
- concept appeared to work -- further calibration needed
  - detected SO_2, glassy surfaces and basaltic mineralogy
  - confirmed avg. 7% emissivity drop in molten basalt (max = 12%)



FLIR filter sequence of Halemaumau crater lava lake spanning ≈ 20 seconds *(Aug 2014)*





Previous Prototype Developments

❖ Field Multispectral FLIR

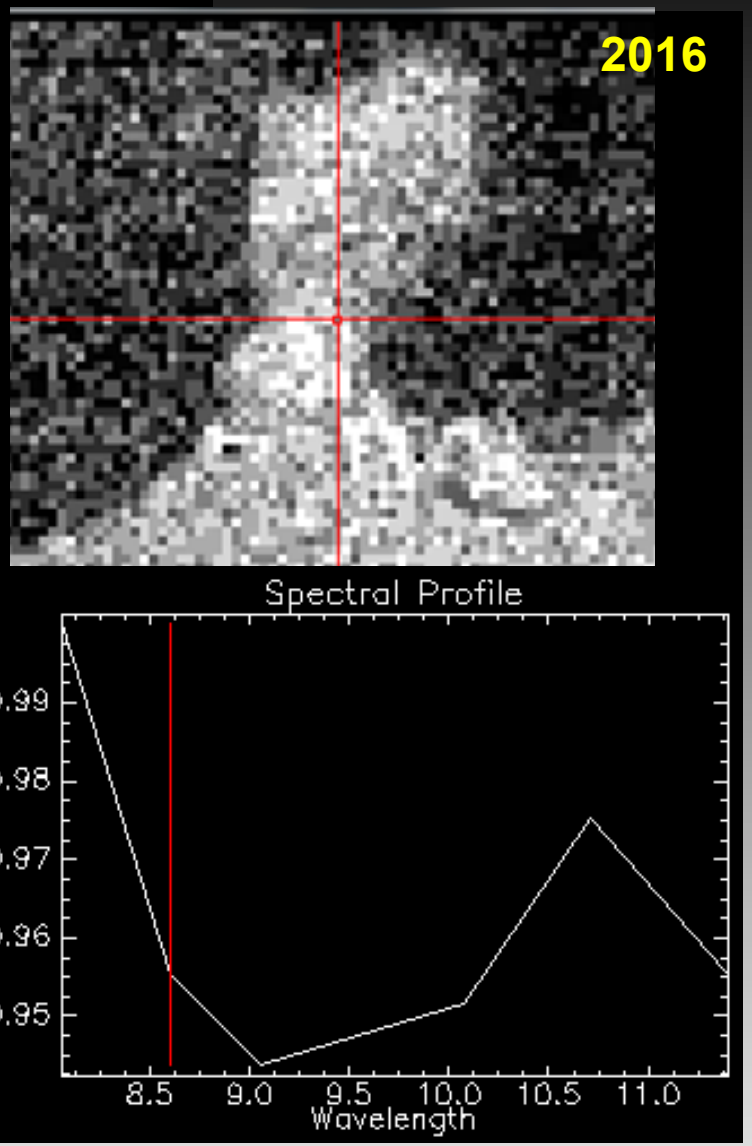
- v. 2.5 tested in Guatemala *(March, 2016)*
  - for detection of ash-plume composition and particle size

Previous Prototype Developments

Previous Prototype Developments

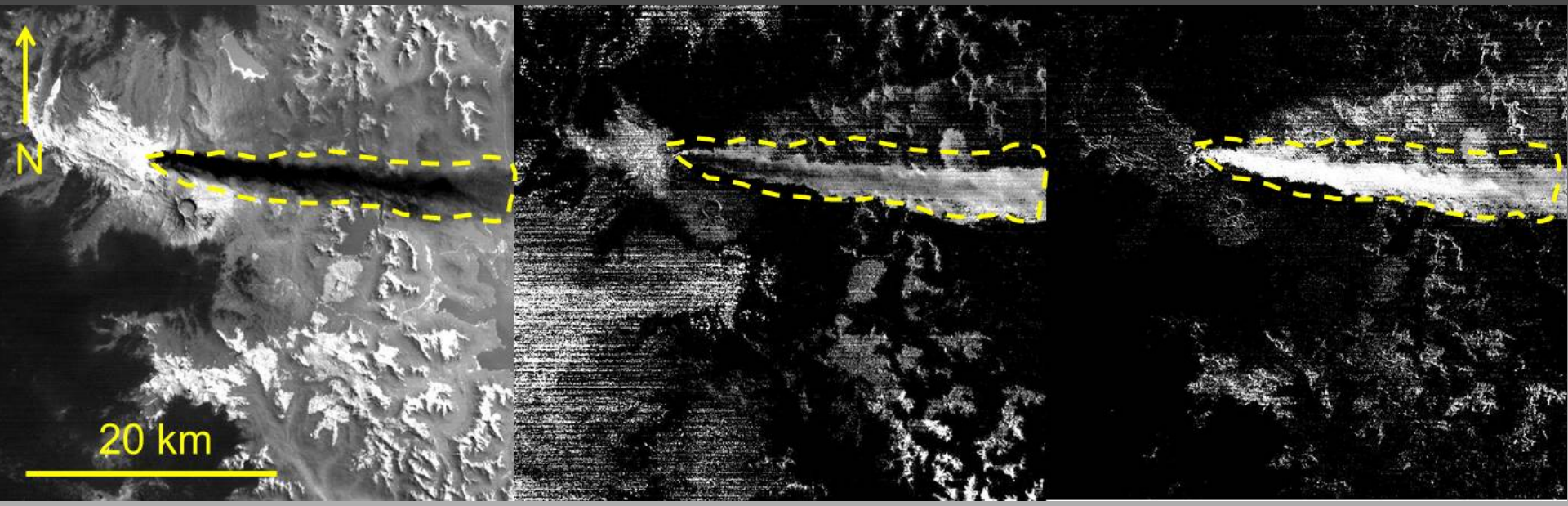
❖ Plume Composition

- Santiaguito volcano *(Mar. 2016)*
  - initial test of the automated camera system
  - spectral data derived for the plume up to 8 km away
  - compared to ASTER-derived results using newly-developed spectral library of ash
- Sakura Jima volcano *(Nov. 2016)*
  - final test of modified camera wheel design and new filter set (v. 2.6)
  - collecting ash samples



ASTER TIR Ash Retrieval

❖ Plume Composition/Size Fractions



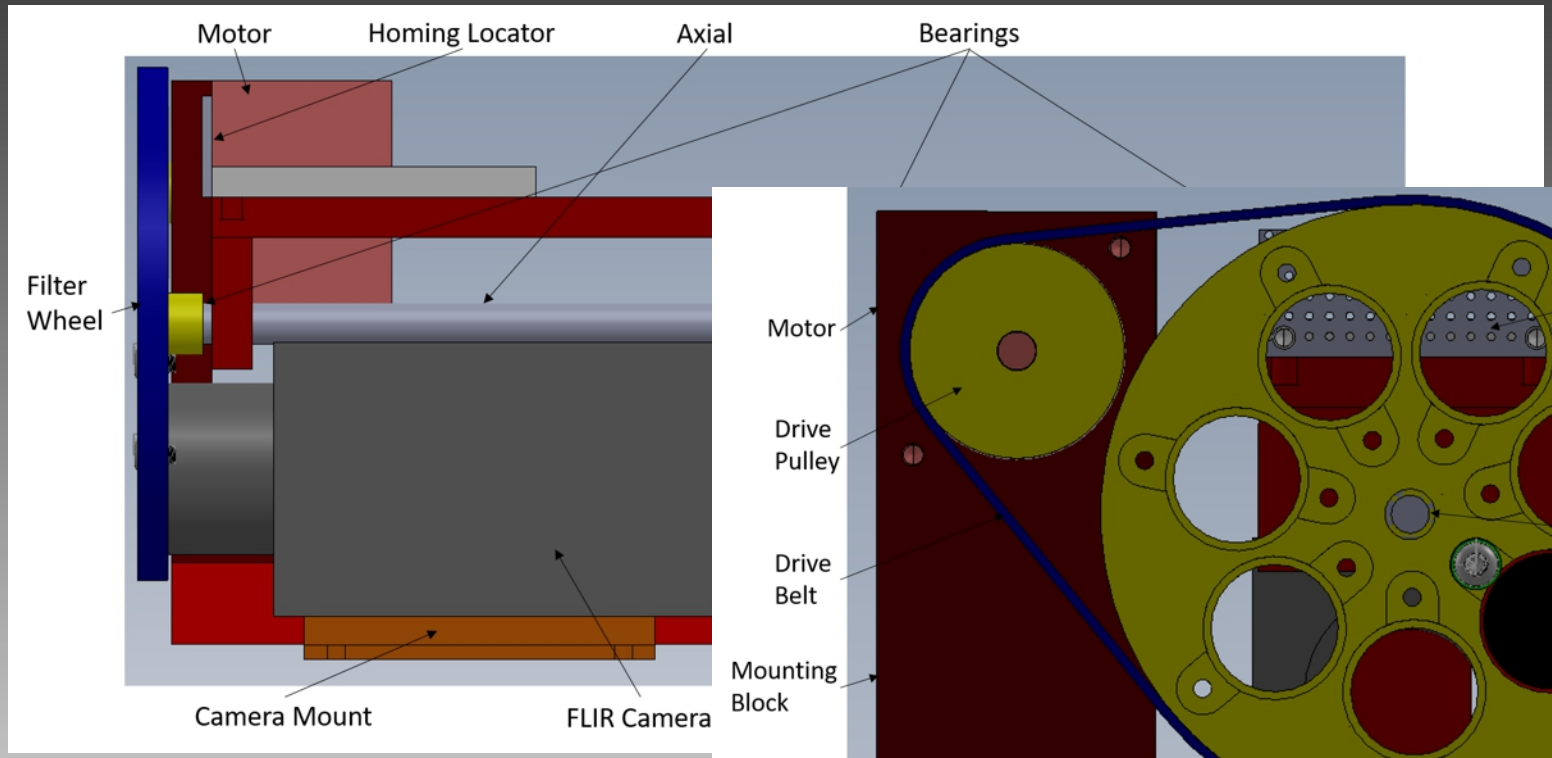
ASTER band 14 radiance image of Puyehue Volcano

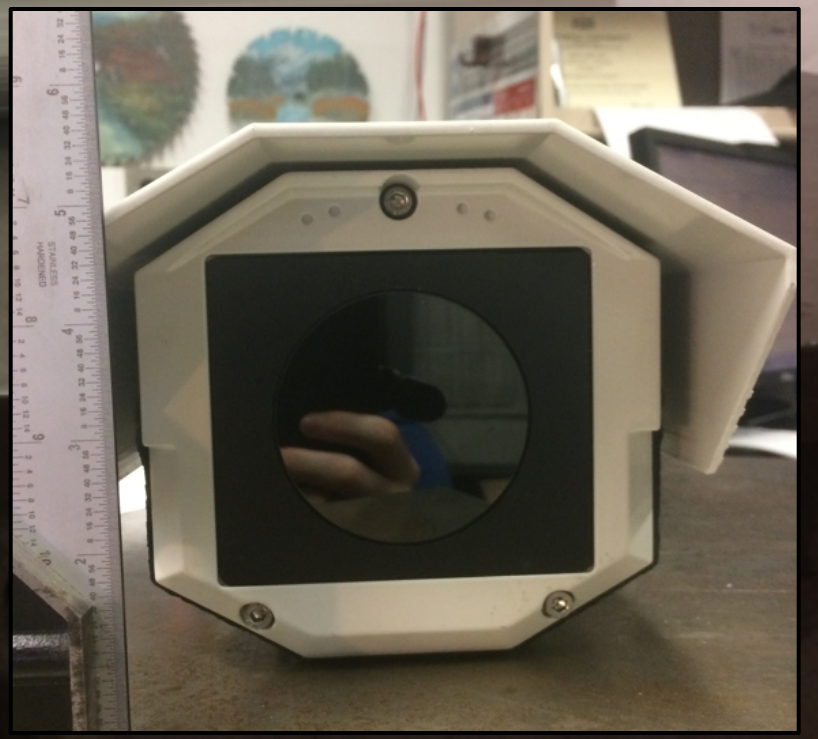
deconvolution result of AST_05 data using the 45 – 75 μm end-member

deconvolution result of AST_05 data using the 5 – 15 μm end-member

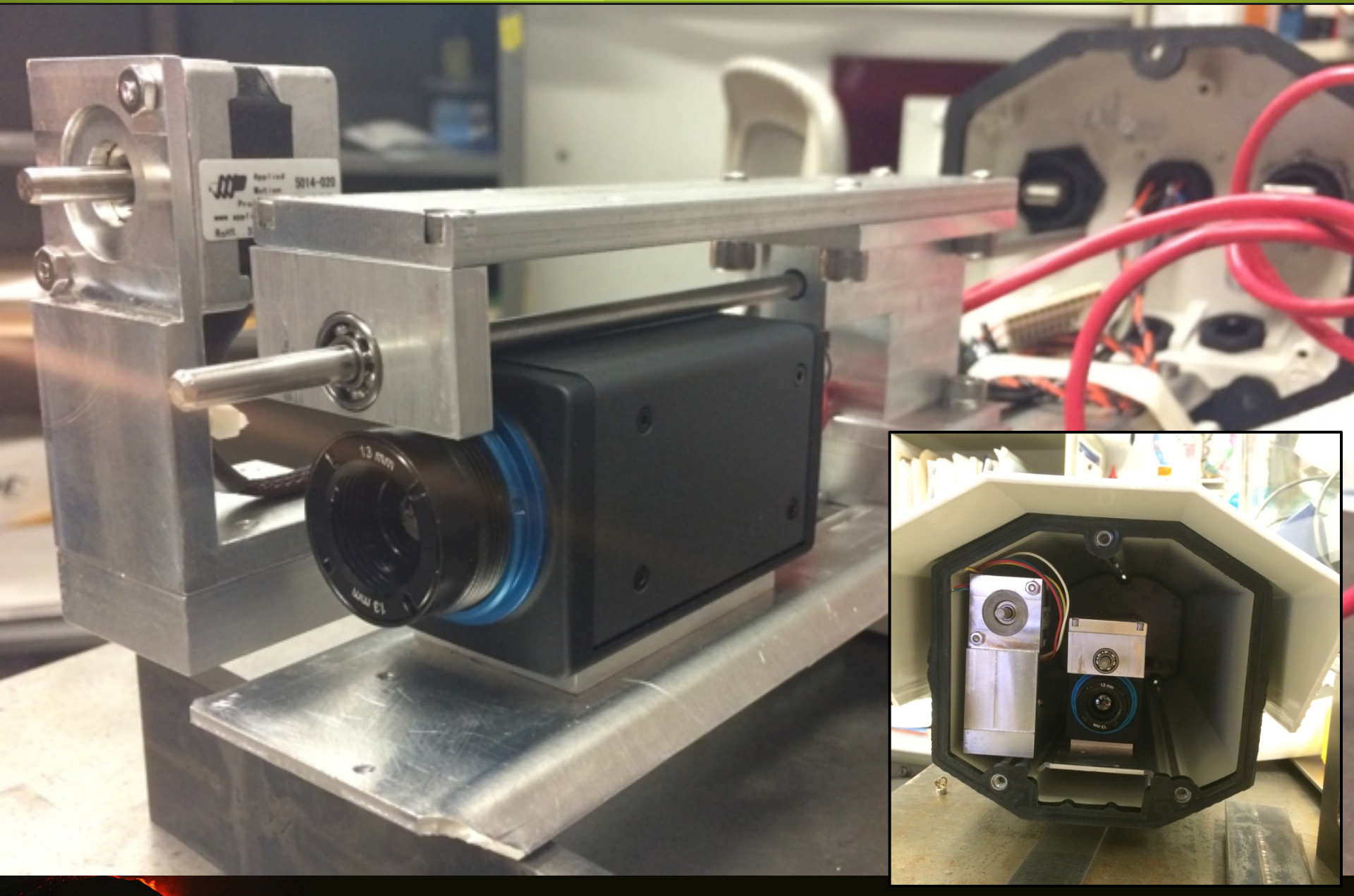
HyspIRI: Proposed Work

❖ Development





HyspIRI: Proposed Work

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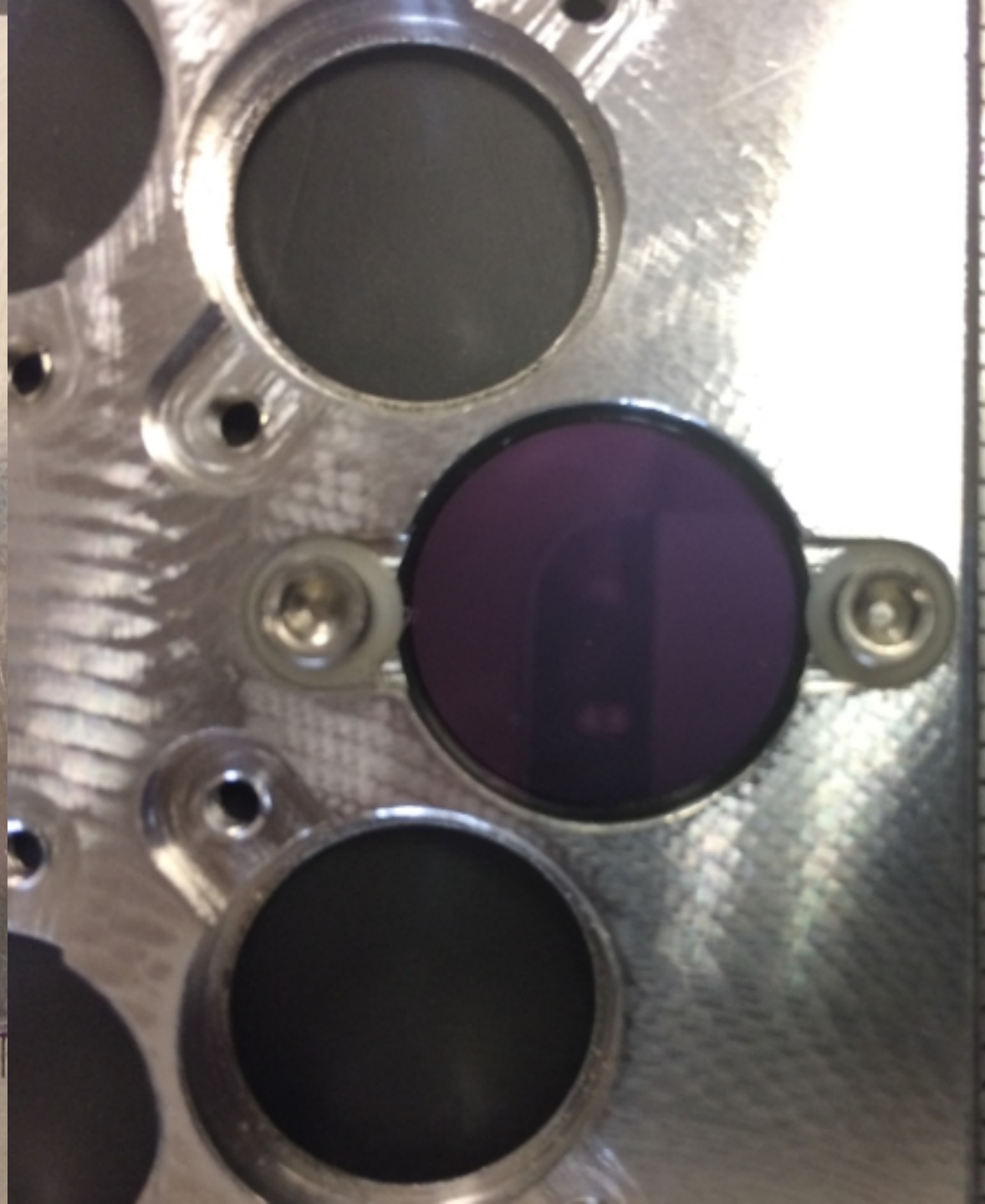

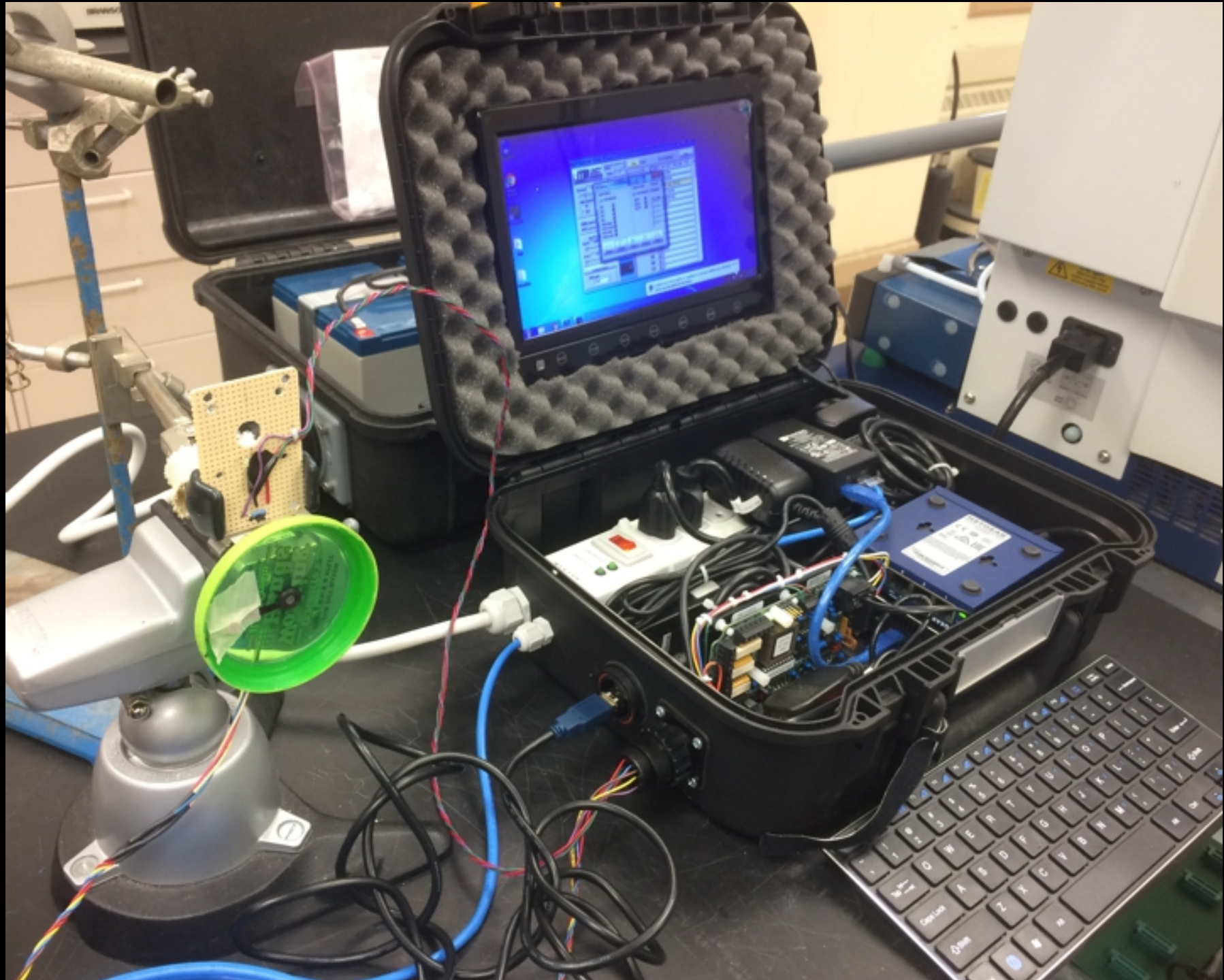

HyspIRI: Proposed Work

❖ Overflight/Campaign Timing

- during the overflights, *in situ* multispectral TIR data will be acquired from the new field instrument
  - at both the active lava lake and the flow field
  - data will be compared/combined with orbital (ASTER) and the airborne (MASTER) and orbital (ASTER) TIR data
    - ➢ to understand the textural, temporal, and thermal trends
    - ➢ quantify the results as they are propagated up through larger pixels
  - then used as input into the lava flow propagation model with a goal of developing a correction approach for thermally-mixed HyspIRI pixels

areas of interest for airborne data coverage

Halemaumau crater, Kilauea (location of active lava lake within nested crater)

HyspIRI: Proposed Work

❖ Proposed Tasks

- Task 2 *(applied science)*: Determine the accuracy of high-temperature emissivity extraction at potential HyspIRI spatial resolutions and its impact on modeling of flow advance
  - Task 2a – Spatial analysis of the HyspIRI analog data
  - Task 2b – Integrated IR measurements and FLOWGO modeling
    - how will the model results be affected?