HyspIRI Preparatory Airborne Science: Investigations of Volcanic Phenomena

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Five Investigations Focused on Active Vents of Kilauea Volcano

Halemaumau Crater, Kilauea Summit Caldera
SO\(_2\) emissions up to 2500 metric tonnes/day since 2008

Puu Oo Vent and Southeast Rift Zone
SO\(_2\) emissions and episodic surface activity since 1983

Rainbow Over Halemaumau
(courtesy of S. Businger)
Understanding Basaltic Volcanic Processes by Remotely Measuring the Links between Vegetation Health and Extent and Volcanic Gas and Thermal Emissions using HysPIRI-like VSWIR and TIR Data

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Chemical desert downwind of Kilauea Summit
Understanding Basaltic Volcanic Processes by Remotely Measuring the Links between Vegetation Health and Extent

Objectives:

- Quantify the effects of volcanic gas and thermal emissions on the surrounding landscape.
- Characterize the spatial and temporal relationships between vegetation cover, surface temperature, and gas ($\text{SO}_2$, $\text{H}_2\text{S}$, $\text{CO}_2$) emissions.
- Evaluate the performance of hyperspectral vs. multispectral vegetation indices in monitoring the health of vegetation.

*Measuring radiant temperature at active fumarole site (photo courtesy of USGS-HVO)*
Understanding Basaltic Volcanic Processes by Remotely Measuring the Links between Vegetation Health and Extent

**Approach:**

- Make diffuse $\text{H}_2\text{S}$ and $\text{CO}_2$ measurements and map local vegetation cover
- Develop hyperspectral vegetation indices (HVI) and hyperspectral narrow bands (HNB)
- Develop hyperspectral libraries
- Develop plant stress gradient models
- Generate surface temperature maps
- Create and test automated change detection algorithms

Hyperspectral narrow bands (HNB) describing plant physiology and stress. Hyperspectral vegetation indices (HVI) are based on sets of contiguous HNB’s (Thenkabail et al., 2013)
Understanding Basaltic Volcanic Processes by Remotely Measuring the Links between Vegetation Health and Extent

Investigation Sites:
In Situ Validation of Remotely Sensed Volcanogenic Emissions Retrievals using Aerostats and UAVs

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In Situ Validation of Remotely Sensed Volcanogenic Emissions Retrievals using Aerostats and UAVs

Objectives:

• In situ validation of ER2-based MASTER/HyTES and AVIRIS gas and aerosol retrievals using free-flying UAV-based, aerostat-based, and ground instrumentation

• Characterize the near surface extent, distribution, constituents, and dispersion characteristics of gas and aerosol emissions from Kilauea Volcano, e.g. SO$_2$ hydrolysis

• To improve accuracy of local SO$_2$ and CO$_2$ flux estimates using in situ airborne data

• Improve approaches to statistical representation of UAV data
In Situ Validation of Remotely Sensed Volcanogenic Emissions Retrievals using Aerostats and UAVs

Approach:

- Deploy Dragon Eye UAVs, aerostats, and ground devices to Kilauea (SO$_2$, CO$_2$; mass spectrometer; nephelometer).
- Conduct science activities that support ER2 and other remote sensing observations (gas/aerosol detects, T, P, H$_2$O profiles).
- Conduct science activities and analyses accessible to in situ observations.
- Proceed with archival activities to take advantage of the JPL/NASA AVA.
In Situ Validation of Remotely Sensed Volcanogenic Emissions Retrievals using Aerostats and UAVs

Investigation Sites:

Aerostat Lift Sites: Red Ovals
UAV Flight Operation Sites: Purple
ER-2 Ground Swath: Yellow
Quantifying Active Volcanic Processes and Mitigating their Hazards with HyspIRI Data

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Andrew Harris, Université Blaise Pascal (France)
I. Matthew Watson, University of Bristol (UK)
Matthew Patrick, USGS Hawaiian Volcano Observatory

IR image of Kilauea flow: Matt Patrick (HVO)
Quantifying Active Volcanic Processes and Mitigating their Hazards with HyspIRI Data

Objectives:

• Quantify the magnitude of temperature-dependent emissivity change for active basaltic surfaces using *in situ* field and laboratory IR data

• Determine the accuracy of high-temperature emissivity extraction at potential HyspIRI spatial resolutions and its impact on modeling of flow advance

*Deployment of V.2.5 multispectral FLIR in Hawaii*
Quantifying Active Volcanic Processes and Mitigating their Hazards with HyspIRI Data

Approach:

- The airborne data will be forward-modeled using a quantitative resampling methodology.
- Ground-based multispectral TIR data will be acquired with new FLIR-based instrument.
- The combined data will be used to validate a correction approach for thermally-mixed HyspIRI data using VSWIR and TIR data.
- Results will be input into flow modeling to better monitor and predict future volcanic hazardous phenomena.
Quantifying Active Volcanic Processes and Mitigating their Hazards with HyspIRI Data

Investigation Sites:

- Halemaumau Crater
- Kilauea Summit Caldera
- Puu Oo Vent and Southeast Rift Zone

Proposed Location of new FLIR system at Halemaumau during overflights
Mapping the Composition and Chemical Evolution of Plumes from Kilauea Volcano: Preparing for the Use of HyspIRI Data to Monitor the Impact of Volcanic Plumes on Air Quality

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MODIS RGB: 9 May 2008
Kona (SW) Wind Conditions

volcanic smog (vog)

Oahu

Hawaii

Honolulu: 15 May 2008
Mapping the Composition and Chemical Evolution of Plumes from Kilauea Volcano

Objectives:

• Prepare for the use of HyspIRI VSWIR and TIR data to monitor the impact of Kilauea SO$_2$ plumes on air quality in the state of Hawaii

• Map the initial concentrations of SO$_2$ and the conversion of SO$_2$ into SO$_4$ aerosols

• Evaluate the impact of HyspIRI-based SO$_2$ and conversion-rate estimates on the skill of the VMAP vog forecast model
Mapping the Composition and Chemical Evolution of Plumes from Kilauea Volcano

**Approach:**

- Collect AVIRIS and MASTER data as analogues for HyspIRI VSWIR and TIR data
- Derive $\text{SO}_2$ concentration estimates from the TIR and $\text{SO}_4$ AOD estimates from the VSWIR
- Validate the retrievals against ground-based measurements collected during deployment
- Evaluate the potential impact of HyspIRI data products on the forecasting skill of VMAP vog model

**Comparison of ASTER-based $\text{SO}_2$ retrievals to measurements from direct-sampling ground station**
Mapping the Composition and Chemical Evolution of Plumes from Kilauea Volcano

Investigation Sites:

Hawaii Health Department Air Quality Stations trace the route of Kilauea plumes

Airborne Coverage: Southern Box

Airborne Coverage: Western Box
Developing an Automated Volcanic Thermal Alert Algorithm using Moderate Spatial Resolution VSWIR and TIR Data: Implications for the Future HyspIRI Mission

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Developing an Automated Volcanic Thermal Alert Algorithm using VSWIR and TIR Data

Objectives:

- Leverage the fine spatial resolution and frequent observations that will be provided by HyspIRI
- Combine VSWIR and TIR measurements
- Improve sensitivity to subtle thermal anomalies
- Incorporate spatial context and temporal variance to minimize false anomalies

High-temperature features at Oldoinyo Lengai Volcano (Tanzania) identified in ASTER VNIR, SWIR, and TIR data (Vaughan et al., 2008)
Developing an Automated Volcanic Thermal Alert Algorithm using VSWIR and TIR Data

Approach:

- Collect AVIRIS and MASTER data as analogues for HyspIRI VSWIR and TIR data
- Employ archived data (e.g. Landsat 8) to establish temporal background
- Validate the alert algorithm against ground-based measurements collected during deployment
- Evaluate the improvements in performance of HyspIRI alert vs. current operation thermal alterations (e.g. MODVOLC)
Developing an Automated Volcanic Thermal Alert Algorithm using VSWIR and TIR Data

Investigation Sites:

- Mauna Loa Summit (sub-boiling fumaroles)
- Kilauea Summit (lava lake)
- Pu‘u o‘o vent
- AVIRIS swath
- MASTER swath
Thank You for Your Attention.