Toward Monitoring the Relationship between Vegetation and Volcanic Activity with HyspIRI

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Project Objective

Demonstrate that vegetation-volcano relationship will be observable by the NASA *Hyperspectral Infrared Imager* (HyspIRI) Mission

Forward (Bio-Response) Question: For known volcanic activity: what is the impact?

Inverse (Bio-Precursor) Question: What do changes in local vegetation tell us about volcano behavior?


we are 4.5 months in the project

Collaborators:

Peter Mouginis-Mark, University of Hawaii
Steven Businger, University of Hawaii
Hyperspectral Infrared Imager (HyspIRI) Mission

Two instruments on the same platform:

Hyperspectral Visible – Near Infrared – Short-wave Infrared

(224 bands, like AVIRIS or Hyperion)

**19 day revisit, global coverage** at 60 m spatial resolution

Multispectral Thermal Infrared

5 day revisit, global coverage at 60 m spatial resolution
Study Site: the Island of Hawaii

SO$_2$ concentrations mapped by the Hybrid Single Particle Lagrangian Integrated Trajectory (HY-SPLIT) and dispersion model

Pu’u O’o vent

Hyperion Swath

Halemaumau vent, opened in 3/2008

Halemaumau vent

Next: Work Plan
Work Plan

1. HyspIRI-like dataset over the eastern side of the Island:
   - VSWIR image time series from Hyperion (during 2006-2011),
   - Thermal IR from ASTER, where available.

2. Investigate the impact of SO$_2$ degassing from Halemaumau vent on the vegetation near the volcano.

   **Major steps:**
   - Map vegetation properties, using PROSAILH model inversion
   - Assess spatial pattern of SO$_2$ distribution, based on HY-SPLIT dispersion model outputs
   - Relate vegetation stress and the SO$_2$ distribution pattern.
SO$_2$ enters leaf tissue through stomata and causes plant injury:

- **Chlorophyll** reduces
- **Carotenoids, Brown Pigment** change (yellowing, browning)
- **Leaf Water Content** (EWT) reduces

Damage magnitude and timing depend on duration and intensity of exposure.

\[ \text{PROSAILH} = \text{PROSPECT} + \text{SAILH} \]


Example: Belridge Orchards, San Joaquin Valley, CA

Pistachio  Almond  Pistachio  Almond

LAI

MASTER: The MODIS-ASTER Airborne Simulator (operated by NASA - Ames)

July 2010:
2 flights same day:
morning & afternoon;
pixel = 7x7 m
We are able to detect small changes occurred over the 4-hour period

EWT decreases:
- where the tree planting structure is different
Vegetation Properties retrieved from Hyperion: the Island of Hawaii

Metrosideros polymorpha
Acacia koa
Native trees/shrubs

Open to closed canopies
Tall (overstory) to moderate (understory) statue trees

Hyperion Images:
1. Dec 1, 2007 (before eruption)
2. Aug 23, 2008 (after eruption)
Leaf Water (Equivalent Water Thickness)

- EWT$_1$
- EWT$_2$
- Δ EWT

Dec 2007 | Aug 2008

Next: Chlorophyll
Leaf Chlorophyll a & b Concentration

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<th>Chl_ab₂</th>
<th>Δ Chl_ab</th>
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Dec 2007 | Aug 2008 | Next: Carotenoids
Leaf Carotenoids Concentration

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<th>Carotenoid₁</th>
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<td>Aug 2008</td>
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Brown Pigment Content

Brown Pigm₁

Brown Pigm₂

Δ Brown Pigm

Dec 2007

Aug 2008

Next: changes summary

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Preliminary Result Summary

1. PROSAI LH inversion appears to work
2. Temporal gradients of biochemical properties are generally consistent with typical patterns of growth and/or damage
3. Different interesting stories for different locations
Questions

Should the observed changes in vegetation be attributed to volcanic activity, and in particular, to the SO$_2$ emissions?

**Forward (Bio-Response) Question:** For known volcanic activity: what is the impact?

**Inverse (Bio-Precursor) Question:** What do changes in local vegetation tell us about volcano behavior?
HyspIRI
image time series

- will allow monitoring vegetation conditions and their changes
- will help formulate hypotheses and locate ROIs
- will help explain changes and detect anomalies

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