Using HyspIRI to Identify Benthic Composition and Bleaching in Shallow Coral Reef Ecosystems

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Overarching Question & Tasks

Will the spectral and spatial characteristics of HyspIRI-like data allow for the accurate retrieval of reef benthic composition, including bleached coral?

1. **Simulation analysis** to characterize the practical limits of discrimination of coral reef benthic composition.

2. **Validation** of benthic fractions from AVIRIS imagery using field observations.
Questions – Simulation Analysis

• What is the minimum fraction of live coral detectable under various water column conditions?

• Which benthic types are difficult to discriminate?

• Under what conditions can we expect good benthic discrimination – what are the no-go conditions?

Answer these questions by examining errors related to unmixing, water conditions, inversion modeling, and atmospheric effects.
Multiple Endmember Spectral Mixing Analysis (MESMA)

- Coral
- Turf Algae
- Sand
- Mixture

Each Mixture Modelled w/ 1000 Endmember Combinations

Mixtures including:
- Live Coral
- Bleached Coral
- Sand
- Algae (Turf, Brown, Green, Red, CCA)

1/10 endmembers
Error Due to MESMA Unmixing
Changes in Reflectance Due to Water Properties

4375 Water Columns

- **Low Chl, Low CDOM, Low Sed., 15m Depth**
- **Med Chl, Med CDOM, Low Sed., 8m Depth**
- **High Chl, Med CDOM, High Sed., 1m Depth**
Error Due to Water Column

Spectral Mixtures → MESMA → Error

Spectral Mixtures + Water Column → MESMA Known H₂O → Error
Error Due to Inversion Model

Spectral Mixtures $\rightarrow$ MESMA $\rightarrow$ Error

Spectral Mixtures + Water Column $\rightarrow$ MESMA Known $\text{H}_2\text{O}$ $\rightarrow$ Error

Spectral Mixtures + Water Column $\rightarrow$ Inversion Model $\rightarrow$ MESMA Derived $\text{H}_2\text{O}$ $\rightarrow$ Error

Lee et al. 1999
Atmosphere at 3 Solar Zenith Angles

High Light  Z = 20.9°

Med Light  Z = 40.1°

Low Light  Z = 59.4°
Error Due to Atmospheric Effects and Correction

- Spectral Mixtures → MESMA → Error
- Spectral Mixtures + Water Column → MESMA Known H$_2$O → Error
- Spectral Mixtures + Water Column → Inversion Model → MESMA Derived H$_2$O → Error
- Spectral Mixtures + Water Column + Atmosphere → Error
- Inversion Model → MESMA Derived H$_2$O → Error

Atm. Correction
Results so far...

- Coral and algae are difficult to separate with MESMA, but not all algal types produce similar errors.

- Derivatives (1\textsuperscript{st} & 2\textsuperscript{nd}) of mixed spectra and endmembers produce better results.
Question – Validation

• How do spectra and modeled benthic fractions from HyspIRI-like imagery compare to field measurements?

1. Benthic fractions derived from phototransects

2. Spectral transects
250 Phototransects Across 5 Hawaiian Islands

- Molokai: 40 Sites
- Oahu: 108 Sites
- Lanai: 32 Sites
- Maui: 40 Sites
- Hawaii: 30 Sites
Phototransect Collection

• 20 meter transects
• 9 GoPro Cameras
• Orthomosiacs created with Photoscan Pro

Photo: Juan Torres-Perez
Phototransect Collection

Photo: Juan Torres-Perez
Classification Using Convolutional Neural Network
Classification Using Convolutional Neural Network
Classification Using Convolutional Neural Network
Olowalu Reef, Maui
AVIRIS 2/22/2017

1km
Spectral Transects (56/250)
Phototransects w/ Spectra
Future Work

• Continue simulation analysis with water columns and atmospheres. We hope to submit a manuscript by the end of the summer.

• Assess relationship between field spectral transects and AVIRIS imagery.

• Continue processing phototransects and begin CNN training.

• Validate fractional cover maps derived from AVIRIS imagery and unmixed using MESMA with field fractional cover estimates.