Internship Project: A comparative analysis of Landsat, AVIRIS, and NIS normalized difference vegetation indices in Domain 17, the Pacific Southwest

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What are NDVIs?

Normalized Difference Vegetation Indices (NDVIs) are used to characterize vegetation, an important aspect of understanding ecosystems. NDVIs are derived using a ratio (Equation 1) between reflectance in the red and near infrared regions of the electromagnetic spectrum. This ratio highlights areas of photosynthesizing vegetation. NDVI values will be closer to 1 in areas of healthy vegetation and closer to 0 in areas with unhealthy vegetation or a lack of vegetation.

\[
\text{NDVI} = \frac{NIR - \text{Red}}{NIR + \text{Red}} \quad \text{Eq. 1}
\]

To determine NDVI sensitivity to NIS spectral band selection, users should compare outputs from NIS and AVIRIS with other sensors, users should spatially resample and compare with Landsat, NDVI maps overlaying Landsat NDVI. This indicates NDVI sensitivity to hyperspectral band selection. Therefore, it is important to specify bands selected for instruments.

Background

The National Ecological Observatory Network (NEON) is constructing an Airborne Observation Platform (AOP) to provide high resolution LIDAR, aerial, and hyperspectral data for NEON sites across the United States. This includes the NEON imaging spectrometer (NIS) that provides more than 420 bands of high resolution data across a spectral range of 380 nm to 2,510 nm. AOP will provide a collection of normalized difference vegetation indices (NDVIs), which use data in the red and near infrared portions of the electromagnetic spectrum to estimate vegetation density and health. A challenge in deriving NDVIs with hyperspectral sensors is band selection and comparability to other sensors. This study analyzed data collected in 2013 from the San Joaquin Experimental Range, CA.

Objective 1 Results: NIS NDVI Band Selection

To determine an optimal band combination for deriving NIS NDVIs, matrices were created (Figure 4). Results showed the greatest contrast between areas of high NDVI returns (healthy vegetation) and areas of low returns (unhealthy vegetation or a lack of vegetation) in the upper left quadrant. This indicates NDVI sensitivity to hyperspectral band selection.

Table 1. Shows the inherent spectral resolution and spatial extent differences between the Landsat, AVIRIS and NIS sensors

<table>
<thead>
<tr>
<th>Sensor</th>
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<th>Spatial Resolution</th>
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</thead>
<tbody>
<tr>
<td>Landsat</td>
<td>7 bands</td>
<td>224 bands</td>
</tr>
<tr>
<td>AVIRIS</td>
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Conclusions and Future Directions

1. NIS NDVI is sensitive to spectral band selection. Therefore, it is important to specify bands selected for use in the NDVI calculation to minimize variation across instruments.
2. Spatial resampling is required to effectively compare high spatial and spectral resolution NIS data to lower resolution sensors such as AVIRIS and Landsat.
3. Subsequent studies could further validate results by analyzing other NEON sites with different vegetation types and by incorporating in-situ data.

4. In the future, data users can use this information to understand the differences between sensors and make informed decisions when selecting data sources.

Objective 2 Results: Comparing NIS, Landsat, AVIRIS NDVIs

To compare with Landsat, NDVI outputs from NIS and AVIRIS were spatially resampled on a 30 m grid (Figure 5). Spatial resampling decreased sensitivity of NDVI to hyperspectral band selection and decreased differences between NIS, AVIRIS and Landsat. This demonstrates that when comparing with other sensors, users should spatially and/or spectrally resample NIS data (see flowchart below).

General Sensor Comparison

Figure 2. Images demonstrating the differences in spatial resolution between 1) Landsat at 30m resolution, 2) AVIRIS at 14.8 m resolution, and 3) NIS at 1 m resolution

Figure 3. NIS true color image with NIS NDVI overlaid. Green trees correctly appear white in the NDVI whereas dead grass appears black.

Figure 4. Matrix demonstrating band selection process for the NEON Imaging Spectrometer (NIS)

Figure 5. Matrix of spatially resampled NIS and AVIRIS NDVI maps overlaying Landsat NDVI.

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