Lecture 6
In situ reflectance measurements

April 22, 2014
Field spectrometry

- Characterizes the reflectance of natural surfaces in the field
- Supports the vicarious calibration of aircraft and satellite sensors
- Performs pilot studies to understand how/if materials can be identified using remote sensing
- In situ reflectance measurements:
  - obtained in the field using a portable spectroradiometer
Why do we collect in situ data?

• To correct data geometrically and radiometrically, so that it is easier to compare remotely sensed data obtained on different dates.

• To develop spectral libraries for identifying targets of interest

• To build models for quantifying biophysical and biochemical properties (e.g., LAI, biomass, foliar chlorophyll content)

Jensen (2006)
Spectroradiometer

• A device used to collect spectral measurements
• Most widely used models:
  – ASD FieldSpec series
  – GER 1500
  – Spectral evolution PSM series
Spectral Reflectance Measurement using a Spectroradiometer

Jensen (2006)
The First Portable Field Reflectance Spectrometer

PFRS 1974

- It collected radiance and reflectance simultaneously.
- It required 2 min to take a sample spectrum and another 2 min to take a reference spectrum.

Picture from Dr. Susan Ustin’s lecture materials.
It still took about 0.5 min to take a spectrum and it weighted ~90 lbs.

Picture from Dr. Susan Ustin’s lecture materials.
NASA JPL ‘Reflectomobile’

Reflectance of intertidal veg

Calibration

Vicarious calibration

Measure off-nadir soil reflectance

NASA JPL ‘Reflectomobile’

Figures from Milton et al. RSE, (2009)
Commonly used spectroradiometers

Some examples of current field spectroradiometers.

<table>
<thead>
<tr>
<th>Spectroradiometer</th>
<th>Spectral region</th>
<th>Optical input</th>
<th>Sensing method</th>
<th>Integral data storage</th>
<th>Wireless comms</th>
<th>Comment</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD FieldSpec Pro FR</td>
<td></td>
<td>Fibre-optic</td>
<td>Dual-beam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASD FieldSpec3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The FieldSpec3 is a development of the FieldSpec Pro FR.</td>
<td>Ocean Optics (<a href="http://www.oceanoptics.com/">http://www.oceanoptics.com/</a>)</td>
</tr>
<tr>
<td>Ocean Optics HR4000/USB2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Miniature spectroradiometer. Modular system with a wide range of optional accessories.</td>
<td></td>
</tr>
<tr>
<td>UniSpec-SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PP Systems (<a href="http://www.ppsystems.com/">http://www.ppsystems.com/</a>)</td>
</tr>
<tr>
<td>UniSpec-DC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Spectra Vista Corporation (<a href="http://www.spectravista.com/">http://www.spectravista.com/</a>)</td>
</tr>
<tr>
<td>GER1500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GER2600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GER3700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVC HR-1024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Employs a PDA with sunlight-readable screen</td>
<td></td>
</tr>
<tr>
<td>PIMA SP^8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>On-board data processing for mineral identification</td>
<td>Integrated Spectronics (<a href="http://www.intspec.com/">http://www.intspec.com/</a>)</td>
</tr>
</tbody>
</table>

Table from Milton et al. RSE, (2009)

Instrumentation technologies have improved since then.
Above-canopy measurements remain a major unsolved problem.

Pictures are from Dr. Susan Ustin’s lecture materials.
Spectral reflectance of a material

• Spectral reflectance of a target material:

\[ \rho_T = \frac{L_T}{L_r} \times k \]

- Radiance from the target
- \( k \) is often close to 1
- Radiance from a reference sample

• Should be collected under the same conditions (atmospheric and illumination).
Reference materials

• Spectralon targets
  – Diffuse reflectance properties
  – Durable and washable
  – Available in a range of reflectances (10%-99%)

Labsphere™ Spectralon targets
A typical reference panel

12.5x12.5 cm

A diffuse white panel in a case

99% reflectance (some claim it as 100%)

A smooth reflectance curve is preferred for calibration panels.
Viewing geometry

• To avoid the BRDF problem, position your detector to view the target at nadir.

\[ D = 2 \times H \times \tan \left( \frac{\beta}{2} \right) \]
Field of view (FOV)

• Calculate the fields of view for a range of foreoptics (H = 1 m):

- 1°
- 3°
- 5°
- 8°
- 18°
- 25°

Fields of view using 1, 5, 8, 18, 25 degree foreoptics positioned 1 m above the target.
Accessories for reflectance measurements

- Fore optics limiting the FOV from $1^\circ$ to $25^\circ$
- Leaf clip for reflectance (black panel) and transmittance measurements (white panel) (Do not cook the leaf!)
- Illuminator reflectance lamp (artificial light source)
Method-produced errors will be introduced, if we use biased procedures:

- Sampling design does not capture the spatial variability of the target of interest
- Improper operation of spectroradiometers
- Uncalibrated spectroradiometers

Capture variation within each land cover (grass) class. From Susan Ustin.
Environmental conditions

• Clouds:
  – The reference spectrum and the target spectrum should be collected under the same conditions. *(Although some references indicate it is acceptable to take canopy reflectance spectra on cloudy days, it is recommended to collect reflectance spectra of crop canopies on clear days to avoid the cloud effects)*

• Wind
  – More difficult to handle
  – Modifies the amount of vegetation, shadow, soil within the IFOV of the spectradiometer
Can we get adequate spectral sampling on the ground?

Ground preparation for airborne flights

Locate Objects Visible in Images and record their coordinates using a GPS:
- Road intersections
- Structures

Identify geolocation and calibration targets:
- Large areas
- Homogeneous
- Dark and bright spectrally invariant targets
- Can be used for 2\textsuperscript{nd} stage spectral improvement

Pictures are from Dr. Susan Ustin’s lecture materials.
Image calibration

Measured Uncalibrated Data (DN)

Instrument Calibration to Radiance (removes instrument noise)

Calibrated Radiance
Image calibration

Atmospheric correction

Reflectance spectrum
(overall shape correct but still has some noise in spectrum)

Calibrated Radiance

2nd stage calibration
(noise reduction)

This step uses in situ reflectance measurements from calibration targets.

Calibrated Reflectance
Fabric targets for calibrating multispectral data

Type 822 target fabric (1.2x1.2 m) in Rugao Experimental fields
Reference panels for image calibration

In situ measured reflectance

Empirical line calibration for a particular band.

\[ y = ax + b \]
Collection of soil spectra at Lost Hills, California (2011)
Further reading materials:
• RSE textbook Chapter 15