SAC-C MMRS Calibration/Validation and an overview of spectral signatures on the basis of AVIRIS information


Sevicio de Aplicaciones CONAE
What was done to achieve the objective and to support the mission?

- A survey among national users intended to serve their needs
- An announcement of opportunity for MMRS mission and the a.m. constellation
  - Desertification processes evaluation and evolution analysis
  - Agriculture applications
  - Forestry
  - Water quality
  - Environmental studies in coastal and fluvial areas
  - Geological applications
- Support natural and anthropogenic disasters

Flooding
Fires
Main requirements

- correct interpretation of scientific information
- image information extraction
- quantification of the results
- use of multi-temporal MMRS data
- synergy of MMRS data with other sensors on board at Landsat 7, EO-1, Terra and AVIRIS

- changes in the sensor performance
  &
- changes in the earth physical processes
a) Generals

<table>
<thead>
<tr>
<th></th>
<th>SAC-C</th>
<th>Landsat 7</th>
<th>AVIRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>altitude [km]</td>
<td>705</td>
<td>705</td>
<td>4</td>
</tr>
<tr>
<td>orbit inclination [°]</td>
<td>98.21</td>
<td>98.21</td>
<td>-</td>
</tr>
<tr>
<td>revise time [days]</td>
<td>16</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>local time descending node (UTM)</td>
<td>10:15</td>
<td>10:00</td>
<td>-</td>
</tr>
<tr>
<td>IFOV [mr]</td>
<td>0.245</td>
<td>0.042</td>
<td>1</td>
</tr>
<tr>
<td>maximum observation angle [°]</td>
<td>14.71</td>
<td>15.39</td>
<td>30</td>
</tr>
<tr>
<td>swath width [km]</td>
<td>360</td>
<td>180</td>
<td>2.1</td>
</tr>
</tbody>
</table>
b) Spectrals and radiometrics (optical bands only)

<table>
<thead>
<tr>
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<th>Landsat 7</th>
<th>AVIRIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of bands</td>
<td>5</td>
<td>6</td>
<td>224</td>
</tr>
<tr>
<td>spectral range (nominal) [nm]</td>
<td>480 - 1700</td>
<td>450 - 2350</td>
<td>380-2500</td>
</tr>
<tr>
<td>spatial resolution [m]</td>
<td>175</td>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>radiometric resolution [bits]</td>
<td>8</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>
Cal/Val Definition

Calibration issues

- Geometric
- Radiometric
- Spectral

- Calibration: set of processes used to determine the relationship between sensor output (DC) and the corresponding sensor input (radiance)

- Validation: set of processes used to assess the accuracy of the derived MMRS data
  - To compare physical magnitudes derived directly or indirectly from MMRS data with simultaneous field observations
  - To compute errors for accuracy assessment
Classification of radiometric calibration procedures

Radiometric calibration

Pre-flight

Relative cal

Absolute cal

Relative cal

On-orbit

Cross cal

Absolute cal

SAC-C MMRS
Landsat 7 TM
AVIRIS
Pre-flight calibration (Generals)

- Knowledge of sensor’s output filling the entire entrance aperture of the sensor with known radiance levels from an integrating sphere for each band

\[ L = g \text{[mwatt.m}^{-2}.\text{sr}^{-1}.\text{count}^{-1}] \cdot DC + b \text{[mwatt.m}^{-2}.\text{sr}^{-1}] \]

- Different radiance levels
- Different temperatures
- Knowledge of sensor’s spectral response for each band:
  - Effective radiance measured by the sensor
  - Wavelength [nm]
Pre-flight: MMRS relative radiometric calibration (1/4)

_Array of 2048 sensors_

\[
L_{\text{sen}} = g_{rk} \cdot \text{DC}_{rk} + b_{rk} \equiv g_{mk} \cdot \text{DC}_{mk} + b_{mk}
\]

\[
\text{DC}_{mk}^{\text{cor}} = \frac{g_{mk}}{g_{rk}} \cdot \text{DC}_{mk} + \frac{b_{mk} - b_{rk}}{g_{rk}}
\]
Pre-flight: MMRS relative radiometric calibration (2/4)
Pre-flight: MMRS relative radiometric calibration (3/4)

Band 3

![Graph showing slope vs. pixel number for Band 3](image)
Pre-flight: MMRS relative radiometric calibration (4/4)

Band 3

Pixel number
Pre-flight: MMRS absolute radiometric calibration

![Graph showing radiance vs digital number for different bands]

- Band 1
- Band 2
- Band 3
- Band 4
- Band 5

Radiance [mw/sr.cm²]

Digital number
On-orbit: MMRS relative radiometric calibration (1/5)

homogeneous areas (including all the pixels)

SAC-C MMRS, R:3 G:2 B:1
On-orbit: MMRS relative radiometric calibration (2/5)

SAC-C MMRS, R:3 G:2 B:1
On-orbit: MMRS relative radiometric calibration (3/5)

SAC-C MMRS, R:3 G:2 B:1

dense vegetation
On-orbit: MMRS relative radiometric calibration (4/5)

SAC-C MMRS, R:3 G:2 B:1
On-orbit: MMRS relative radiometric calibration (5/5)

SAC-C MMRS, R:3 G:2 B:1
On-orbit calibration: Cross-calibration

One sensor system is used to check the calibration on a second

Conditions:
- Nearly coincident acquisitions between sensors
- Approximately equal spectral radiance at TOA along a common sight

For each band:

\[
\begin{align*}
g^{(SR)} \cdot DC^{(SR)}_1 + b^{(SR)} &= g^{(S1)} \cdot DC^{(S1)}_1 + b^{(S1)} \\
g^{(SR)} \cdot DC^{(SR)}_h + b^{(SR)} &= g^{(S1)} \cdot DC^{(S1)}_h + b^{(S1)}
\end{align*}
\]

S: MMRS
SR: Landsat 7-TM
AVIRIS
On-orbit calibration: Ground truth - Validation

For each band

\[ \begin{align*}
\mathbf{L}_\text{sen}^l &= g'. DC^l + b' \equiv \mathbf{L}_\text{pix}^l + \mathbf{L}_\text{atm}^l + \mathbf{L}_\text{env}^l \text{(homo)} \\
\mathbf{L}_\text{sen}^h &= g'. DC^h + b' \equiv \mathbf{L}_\text{pix}^h + \mathbf{L}_\text{atm}^h + \mathbf{L}_\text{env}^h \text{(homo)}
\end{align*} \]

\[ (g', b') \]

\( \checkmark \mathbf{L}_c |_{\text{MMRS}} \)
\( \checkmark \mathbf{L}_c |_{\text{AVIRIS}} \)
\( \checkmark \mathbf{L}_c |_{\text{radiometer}} \)

\( \mathbb{S} \) AVIRIS campaign
\( \mathbb{S} \) in situ measurements
On-orbit calibration: Ground truth – Validation (Flow chart)

DN’s – MMRS (spectral signatures)

radiometric correction
($L_{sen} = g \times DC + b$)

atmospheric correction

$L_{c|MMRS}$

$g^*, b^*$

$L_{c|AVIRIS}$

$g^#, b^#$

AVIRIS (spectral signatures)

atmospheric correction

integration according to MMRS spectral responses
AVIRIS campaign (3/2)

Landsat 7 TM
7 February 2001

SAC C MMRS
8 February 2001
“Salar de ARIZARO” Campaign (1/3)
“Salar de ARIZARO” Campaign (2/3)
“Salar de ARIZARO” Campaign (3/3)
“Salar de ARIZARO” Reflectance Measurements