HISUI Vicarious calibration and Cal/Val activities

Hirokazu YAMAMOTO (GSJ, AIST)
Kenta OBATA (GSJ, AIST)
Toru KOUYAMA (ITRI, AIST)
Satoshi TSUCHIDA (GSJ, AIST)
Introduction

• The Hyperspectral Imager Suite (HISUI) is the Japanese next-generation Earth observation project, and is being developed by Japanese Ministry of Economy, Trade, and Industry (METI).

• HISUI Calibration Working Group considers the following calibration methods.
  – Onboard Calibration: Calibrated using the calibration device on satellite
  – Vicarious Calibration: Calibrated by simultaneous ground measurement
  – Cross Calibration: Calibrated using other satellite instruments
  – Lunar Calibration (TBD): Calibrated by viewing the moon (stable radiance)*
# Specifications of HISUI Multispectral Imager and Hyperspectral Imager

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hyperspectral Imager</th>
<th>Multispectral Imager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaging Type</td>
<td>Pushbroom</td>
<td>Pushbroom</td>
</tr>
<tr>
<td>Spatial Resolution / Swath</td>
<td>30 m / 30 km</td>
<td>5 m / 90 km</td>
</tr>
<tr>
<td>Spectral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bands</td>
<td>185</td>
<td>4</td>
</tr>
<tr>
<td>Range</td>
<td>0.4 - 2.5 µm</td>
<td>0.485 - 0.835 µm</td>
</tr>
<tr>
<td>Resolution</td>
<td>10 – 12.5 nm</td>
<td>60 – 110 nm</td>
</tr>
<tr>
<td>SNR (30% albedo)</td>
<td>≥ 450 @620 nm</td>
<td>≥ 200</td>
</tr>
<tr>
<td></td>
<td>≥ 300 @2100 nm</td>
<td></td>
</tr>
<tr>
<td>MTF</td>
<td>≥ 0.2</td>
<td>≥ 0.3</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>Saturated at 70% albedo</td>
<td></td>
</tr>
<tr>
<td>Spectral Calibration</td>
<td>VNIR : 0.2 nm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWIR : 0.625 nm</td>
<td></td>
</tr>
<tr>
<td>Radiometric Calibration</td>
<td>Absolute : ±5%, among bands : ±2%</td>
<td></td>
</tr>
<tr>
<td>Quantization</td>
<td>12 bits</td>
<td></td>
</tr>
<tr>
<td>Data Compression</td>
<td>Lossless (70%)</td>
<td></td>
</tr>
<tr>
<td>Pointing</td>
<td>Cross track : ± 3 °</td>
<td>N/A</td>
</tr>
</tbody>
</table>
We try to increase vicarious calibration frequency using both of northern hemisphere and southern hemisphere.
CSIRO set up the CIMEL site, which is known as Aeronet (http://aeronet.gsfc.nasa.gov/) station close to Lake Lefroy in 2012, and ground-based atmospheric data can be downloaded from Aeronet since June, 2012.
Field Campaign on Nov 26, 2013 (Lake Lefroy, Australia).
Field Campaign on Nov 26, 2013 (Lake Lefroy, Australia).

ASTER image Captured on Nov 26, 2013
Morning Constellation satellites

A view of the Earth with EO-1 above showing instrument swath widths
(Pearlman, Carman, and Segal, 2001)
http://eo1.gsfc.nasa.gov/new/validationReport/Technology/T
RW_EO1%20Papers_Presentations/05.pdf

The EO-1 satellite flies in an orbit that covers the same ground track as Landsat 7, approximately one minute later, and then Terra satellite flies in the same orbit after approximately 30 minutes.

Nov. 26, 2013:
- Field Campaign
- Terra ASTER
- Landsat-7 ETM+

Dec. 12, 2013:
- EO-1 ALI
- EO-1 Hyperion
- Landsat-7 ETM+
MOD08_D3, MISR L3, and Aeronet@LLF

AOT on Nov. 26

MOD08_D3 generated by NASA Giovanni (http://disc.sci.gsfc.nasa.gov/) (AOT@550[nm] <??)

Aeronet (Lake Lefroy (AOT@500[nm] (Ver1.5) : Approx. 0.06-0.07)

FC Ground measurement
(Nov 26, 2013):
AOT@550[nm] = 0.037
MOD08_D3 and Aeronet@LLF
AOT on Dec. 12

MOD08_D3 generated by NASA Giovanni
(http://disc.sci.gsfc.nasa.gov/)
(AOT@550[nm] : ??)

Aeronet (Lake Lefroy)
(AOT@500[nm] (Ver1.5) : Approx. ??)

MISR L3 product ends on Nov 30, 2013.
MOD08_D3 and Aeronet@LLF
Water Vapor on Nov. 26

MOD08_D3 generated by NASA Giovanni
(http://disc.sci.gsfc.nasa.gov/)
(Water Vapor: Approx. 2.0 ?)

FC Ground measurement (Nov 26, 2013) :
Water Vapor = 1.24 [cm]

Aeronet (Lake Lefroy)
(Water Vapor (Ver1.5) : Approx. 1.7-1.8)
MOD08_D3 and Aeronet@LLF
Water Vapor on Dec. 12

MOD08_D3 generated by NASA Giovanni
(http://disc.sci.gsfc.nasa.gov/)
(Water Vapor: Approx. 2.0 ?)

Aeronet (Lake Lefroy)
(Water Vapor (Ver1.0) : Approx. ??)
Aura OMI L3 Column Amount Ozone on Nov 26 and Dec 12, 2013

Aura OMI L3 generated by NASA Giovanni (http://disc.sci.gsfc.nasa.gov/)
(Column Amount Ozone: Approx. 275-300 on Nov 26, 2013

FC Ground measurement (Nov 26, 2013) :
Ozone = 309.4 [DU]
Surface reflectance factors are derived by using Spectralon white reference panels. We need to evaluate white reference panels we use.
Spectral Irradiance

CEOS recommended solar irradiance spectrum (Thuillier 2002)

SUN01kurucz2005 irradiance model is included in MODTRAN5 code.

400-2384 [nm] : Thuillier 2002
2384 -2500[nm] : SUN01kurucz2005
Comparison of TOA radiance

We need to evaluate the accuracy around the radiance/reflectance affected by water vapor absorption.
Cross-calibration

We are going to establish the algorithm of cross-calibration for HISUI.
Lunar Reflectance Model based on SELENE/SP (Spectral Profiler) data

Reflectance map [Yokota et al., 2011]

Geometrical dependencies on incident, emission and phase angles

By using the model, we can simulate/predict any moon observation.

April 13, 2003  April 15  April 18

530 – 1600 nm (160 channels)
\( \Delta \lambda = 6 - 10 \text{ nm} \)
0.5° x 0.5° grid interval
→ 1~2 pixel size of ASTER/VNIR (observing from Earth)
Application of HISUI Calibration parameters

GDS (Ground Data System)

L0B data for Geo/Cal

Geometric

Geo/Cal (L1) WG

Band alignments
Pixel alignments
GCP check

Radiometric

Rad/Cal WG

Onboard cal.
Vicarious / Cross cal.
Lunar cal.

GCP

Geometric calibration tables

Archives

Renewing
Every ** months

Renewing
Every 6 months

Archives

Reviewing
every year?

FC data
Other satellite data

Archives

L0B data for Rad/Cal

Renewing
Every ** months

Reviewing
every year?
Conclusions

- EO-1 Hyperion, ALI, Terra ASTER with ground-based data by vicarious calibration experiment is useful as HISUI vicarious calibration and cross-calibration in the pre-launch phase. We continue to evaluate the vicarious calibration and cross-calibration using these satellite sensors.
- We will develop an algorithm of the cross-calibration for HISUI sensor.
- We should consider evaluation of obtained reflectance factor around water vapor absorption band for vicarious calibration.
- White reference panel plays a key role on reflectance approach for vicarious calibration measurement because we use NIST traceable panel. We also plan to understand the characteristics of difference between NIST traceable panel and the white reference panel used in field campaign.
- HISUI Calibration Working group considers the lunar calibration for HISUI using Lunar Reflectance Model based on SELENE SP data.
- HISUI Calibration Working group is going to arrange the calibration archive system due to renewing HISUI calibration parameters.
Example of averaged surface reflectance factor

Ivanpah Playa

Railroad Valley

Lake lefroy

Lake lefroy