The Calibration of AVHRR/3 visible dual gain using Meteosat-8 as a MODIS calibration Transfer Medium

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Motivation

• Climate Absolute Radiance and Refractivity Observatory (CLARREO) Mission - designed to calibrate other imagers
  – put calibration resources into CLARREO, imagers can focus on mission requirements and can use CLARREO as a calibration reference
  – Employs radiometers requiring a footprint of 100km in order to spectrally resolve the shortwave radiance.

• AVHRR/3 employs a dual gain in the visible
  – No onboard visible calibration
  – GAC has global coverage and is a 3x5 km subset of the HRPT
    • No special operations needed, when matching to a 100km FOV

• To transfer the CLARREO calibration to AVHRR/3 the dual fit must be solved simultaneously
  – Both high and low counts will be present in a 100km FOV
Methodology

• Use MODIS as the calibration reference
• MODIS and AVHRR/3 coincident visible matches occur at 70°N latitude
  - Only during June and July is there enough of a high count dynamic range to effectively calibrate the high counts
• Use Meteosat-8 as a calibration transfer medium
  - Equatorial matches ensure bright targets to resolve high gain
  - Meteosat-8 has all 3 AVHRR/3 visible channels
  - Calibrate Meteosat-8 with MODIS
  - Calibrate AVHRR/3 with Meteosat-8
• Develop statistical package to derive dual gains
  - Verify space count, break point continuity, gain ratio
  - Monitor gains over time for degradation and monthly gain noise
Dual Gain Regression Methods

- Constant space count (SPC) or determine offset (OFF)
  - AVHRR incorporates a space clamp
- Low gain tied to high gain (TIED) or dual gains (DUAL)
  - There is one detector and optics, high gain a multiple of low gain
- Continuous breakpoint (CONT) or gap between high and low counts (GAP)

<table>
<thead>
<tr>
<th>SPC</th>
<th>SPC</th>
<th>SPC</th>
<th>OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIED CONT 1COF</td>
<td>TIED GAP 2GAP</td>
<td>DUAL GAP 3SPC</td>
<td>DUAL GAP 4COF</td>
</tr>
<tr>
<td>CONT 2DUAL</td>
<td>CONT 2OFF</td>
<td>CONT 3CONT</td>
<td></td>
</tr>
</tbody>
</table>
Example of Regression methods

- Randomly generate GAC pixel counts in 50 km FOV using prescribed space count, no gap, and tied gains
- Calculate 95% confidence limits for each method

Each point represents a 50 km FOV

Estimated gain ratio=7.2, radiance gap = 55.4, space count=-262.7
prescribed gain ratio=2.8, radiance gap = 0.0, space count=83.3
Gain ratio=2.8, radiance gap = 0.0, space count=83.3

Est Gain Ratio=3.0

Est radiance gap=23.1

Est space count=81.1

Est space count given No gap allowed

2dual

2gap

2off

1cof
AVHHR/3 Regression Strategy

• Using monthly scatter plots, employ the 2 degree of freedom regressions to isolate the space count, breakpoint radiance gap, or gain ratios
  – Make adjustments if necessary
• Monitor 1COF regressions over time to quantify monthly noise and determine degradation
  – 1COF with one degree of freedom has a small uncertainty at the 95% confidence limit
• Validate AVHRR calibration with nominal (pre-launch) and direct MODIS/AVHRR (polar) comparisons
Cross-Calibration Method

- Match mean radiance or count within a 0.5° region (50km)
  - Scattering angle within 10°, < 10 minutes, no sunglint, normalize to common SZA and solar constant, and 0.2 spatial sigma threshold
- Perform monthly linear regressions to derive gain
- Compute degradation from a time line of monthly gains

Visible standard error (%) as a function of:

- FOV
- TIME
- Spatial Sigma
MET-8/Terra-MODIS
Feb 07

MODIS 0.86µm saturates

- 5% FOV sdev used
- further uniformity reduction results in loss of dynamic range
**Comparison of Met-8 gains (stderr%) compared with EUMETSAT**

<table>
<thead>
<tr>
<th>Channel</th>
<th>Feb07</th>
<th>EUMETSAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65μm</td>
<td>0.62 (3.1%)</td>
<td>0.59</td>
</tr>
<tr>
<td>0.86μm</td>
<td>0.53 (4.1%)</td>
<td>0.45</td>
</tr>
<tr>
<td>1.64μm</td>
<td>0.88 (3.5%)</td>
<td>0.88</td>
</tr>
</tbody>
</table>

- 0.65μm Theoretical spectral correction = .9741 MET8/Terra
- 0.62*.9741=0.60
- Within 2% of EUMTETSAT
Spectral Response Functions

- No attempt is made for normalizing spectral response functions

- MET8 and AVHRR most similar in the 0.65µm channel, however there are ozone absorption differences
- Note very little overlap between MET8 and AVHRR in the 0.86µm channel
• Gray (mixed) points are where either high or low counts < 97%

• The gain has degraded 8% from nominal compared to MET8/MODIS after 5 years in orbit
MET8/NOAA-17, Feb07

0.86µm

- 44% degradation with MET8/MODIS
- 27% degradation with EUMETSAT

1.64µm

- 31% degradation with MET8/MODIS
Example of gain ratio adjustment

Nominal gain ratio = 7

Gain Ratio = 6.0

- 5% standard error reduction changing gain ratio from 7 to 6

<table>
<thead>
<tr>
<th>FIT</th>
<th>GAIN1</th>
<th>Coff1</th>
<th>Gain2</th>
<th>Coff2</th>
<th>ERR%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4COF</td>
<td>0.025</td>
<td>-28.42</td>
<td>0.164</td>
<td>418.0</td>
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<tr>
<td>3CONT</td>
<td>0.028</td>
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<td>0.171</td>
<td>424.2</td>
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<td>3SPC</td>
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<td>0.165</td>
<td>419.2</td>
<td>8.88</td>
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<tr>
<td>3TIED</td>
<td>0.024</td>
<td>-22.83</td>
<td>0.170</td>
<td>421.7</td>
<td>8.78</td>
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<tr>
<td>2DUAL</td>
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<td>-40.00</td>
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<td>422.6</td>
<td>9.08</td>
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<tr>
<td>2OFF</td>
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<td>431.9</td>
<td>9.54</td>
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<tr>
<td>2GAP</td>
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<td>-40.00</td>
<td>0.186</td>
<td>431.7</td>
<td>9.28</td>
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<td>NOM</td>
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<td>-42.09</td>
<td>0.143</td>
<td>436.8</td>
<td>10.22</td>
</tr>
</tbody>
</table>

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Effect of mixed low/high count FOV
Feb07, 0.86µm, no FOV sdev threshold

- Gray (mixed) FOVs are where either high or low counts < 97%
- Only mixed FOVs < 97%
- All regression gains within 2%
Monitor dual gains over time
Jan07-Apr07, 0.65µm, MET8/N17

• would rely on 1COF for timeline given smallest gain uncertainty
Monitor dual gains over time
Jan07-Apr07, MET8/N17

0.86µm

1.64µm
Conclusions

• NOAA-17 AVHRR visible channels have been calibrated against MET-8/MODIS using dual gain regressions based on 50 km FOV.
  – Method can be used with CLARREO and AVHRR
  – Method able to determine both gains simultaneously

• MODIS/MET-8 calibration are very similar to EUMETSAT except the 0.86µm due to MODIS saturation
Future Work

• Complete following timelines from present to Sep 2002
  – NOAA-17/MET-8
  – MET-8/Aqua-MODIS
  – NOAA-17/Aqua-MODIS

• Validate calibration by performing 3-way cross calibration
  – NOAA-17/MET-8 * MET-8/Aqua-MODIS = NOAA-17/Aqua-MODIS

• Possibly perform sequence on GOES-10/11 for the 0.65µm channel