CALIBRATION AND VALIDATION ACTIVITIES IN THE LAST YEAR

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RapidEye AG, Brandenburg / Havel
• RapidEye calibration concept in general, assumptions and requirements

• Flat Fielding using the side slithering approach

• Inter-Constellation Cross Calibration (Status)

• Absolute Calibration (Status and plans for 2012)

• Geometric Accuracy Assessment

• Forecast
Assumptions and Requirements of the calibration concept

- Each detector of one band delivers the same DN when excited to the same radiance (flat fielding).

- The individual cameras are cross calibrated to within 5%.

- The response is stable over the full mission lifetime.

- The cameras are absolutely calibrated to radiance.

- The geometric accuracy of all cameras is consistently better than 2 pixels (dependent on the availability of GCPs and DEM).
SPATIAL CALIBRATION (FLAT FIELDING)

Ensures uniform radiometric response over all detectors

Two Methods for Spatial Calibration are used

**Statistical Approach:** Mean detector responses over a period of time are collected (a certain amount of data is needed to equal out surface influence).

**Side Slither Approach:** Spacecraft is yawed by 90°, so every detector sees the same ground pixel (specially configured imaging is necessary).

The statistical spatial calibration technique involves collecting a large number of standard images to update the correction factors.

The side slither technique allows to create correction factors from only one (specifically collected) image.
Data obtained during a side slither maneuver only excites the sensor at one radiance level, so another data set needs to be used to fully characterize the response curve.

Detector offsets = Pacific Night Shot Column Means

New Moon over the pacific ocean (ascending node image)
USED SITES

Saudi Arabia  Greenland  Antarctica (Dome C)
RESULTS

A Temporal Calibration approach is used to achieve stability over time and between the constellation.

26 calibration sites are imaged every month by every SC.

A statistical approach is used to control and update the correction factors.
The tile mean values are compared against a baseline response common to all spacecraft.

The plot shows the deviation of the respective band to the common baseline (as of end of March 2012)

<table>
<thead>
<tr>
<th></th>
<th>RE1</th>
<th>RE2</th>
<th>RE3</th>
<th>RE4</th>
<th>RE5</th>
<th>MAX-MIN</th>
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</thead>
<tbody>
<tr>
<td>Blue</td>
<td>0.2849 %</td>
<td>-1.1856 %</td>
<td>-0.7116 %</td>
<td>-0.5363 %</td>
<td>-1.6566 %</td>
<td>1.9415 %</td>
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<tr>
<td>Green</td>
<td>-0.4479 %</td>
<td>-1.0581 %</td>
<td>-0.2722 %</td>
<td>-0.2087 %</td>
<td>-1.6628 %</td>
<td>1.4541 %</td>
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<tr>
<td>Red</td>
<td>0.6952 %</td>
<td>-1.0926 %</td>
<td>-0.2290 %</td>
<td>-0.2309 %</td>
<td>-1.1400 %</td>
<td>1.8352 %</td>
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<tr>
<td>Red-Edge</td>
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<td>-0.5017 %</td>
<td>0.4408 %</td>
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<tr>
<td>NIR</td>
<td>0.3529 %</td>
<td>-0.6143 %</td>
<td>-0.3344 %</td>
<td>0.1295 %</td>
<td>-0.7631 %</td>
<td>1.116 %</td>
</tr>
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</table>
ABSOLUTE CALIBRATION

Vicarious Calibration Approach

Railroad Valley (Nevada) serves as the calibration site.

Field measured reflectance and atmospheric transmission is used to predict TOA radiance.

Sensor Gain and Offset are updated to incorporate results if necessary.
Absolute calibration campaigns

- 2009 / 2010 Ivanpah Playa and Railroad Valley Playa, 10 field events with 2 satellites (7 calibration and 3 verification events)
  - absolute calibration of RE3 and RE4 combined with relative radiometric calibration of the constellation transfers absolute radiometric uncertainty to each sensor

- 2011 Railroad Valley Playa, 5 field events with all satellites (1 per SC)
  - Small event due to organizational changes and changes of ownership was meant to control the development of the radiometric sensor behaviour (2 unreliable or unusable due to cloud coverage).

- 2012 Railroad Valley Playa, 20 field events with all satellites are planned between April (successfully finished) and October 2012
Results from the 2010 verification event showed that the sensor performance is better than 4% deviation from the ground measurement (Naughton et al, Jacie, 2011)

Snapshot Deviations between the radiances predicted from field measurements and MSI measured (%) from the 2011 campaign.

<table>
<thead>
<tr>
<th></th>
<th>RE3</th>
<th>RE4</th>
<th>RE5</th>
<th>Mean</th>
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</thead>
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<tr>
<td>Blue</td>
<td>3.32</td>
<td>4.84</td>
<td>4.72</td>
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<tr>
<td>Green</td>
<td>5.68</td>
<td>6.47</td>
<td>6.66</td>
<td>6.27</td>
</tr>
<tr>
<td>Red</td>
<td>4.52</td>
<td>1.69</td>
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<tr>
<td>Red-Edge</td>
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<tr>
<td>NIR</td>
<td>3.08</td>
<td>4.36</td>
<td>5.21</td>
<td>4.22</td>
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</tbody>
</table>

RE1: not reliable due to cirrus cloud coverage during satellite overflight and field measurement

RE2: thunderstorm during satellite overpass prohibited field measurements
On a regular basis the geometric accuracy of image products is monitored.

- Images from structured areas.
- Very good reference information available (GCPs and DEM).
- Flat as well as rough terrain areas are used (e.g. Sioux Falls, SD and Pueblo, CO).
Geometric accuracy goals are meat for all products.

Most products are even better than 1 GSD (6.5m)
FORECAST until the end of 2012

- Completion of absolute calibration campaign and update if necessary
- Update of MTF evaluation
Thank You very much

2009 - 2011
Imaging Frequency.
Numbers of images taken

- up to 5
- up to 10
- up to 20
- up to 50
- more than 50  Cloud Coverage < 20%

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