Section 2

Image quality, radiometric analysis, preprocessing

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Radiometric Quality
(refers mostly to Ikonos)

Preprocessing by Space Imaging (similar by other firms too):

- **Modulation Transfer Function Correction (MTFC)**
  Always performed
  Sharpen image especially in scan direction due to TDI imaging (typically 13 lines) or due to satellite rotation during imaging of one line, which cause blurring

- **Dynamic Range Adjustment (DRA)**
  Performed optionally
  Stretch grey values to better occupy grey value range

Some artifacts are due to compression from 11 to 2.6 bit (visible esp. in homogeneous areas)
With some sensors compression up to factor 9 (ALOS) or 10 (Resurs-DK-1) are applied!
**Radiometric Quality**

11bit histogram Nadir PAN (Melbourne) - without DRA

DRA stretches the grey values (GVs) to cover more uniformly the 11 bit range.

Result: Absolute radiometric accuracy is destroyed + leads to combination of GVs that are not frequently occupied. Better methods of contrast stretch exist.

Suggestion: order images with DRA only for 8-bit images and visual (manual) processing.
Radiometric Quality

Important aspects for Feature Extraction and Interpretation

Pan-Sharpened 1m *Ikonos* (7° tilt, summer end)

Stereo 1m *Ikonos* (29° tilt, winter)

- View angle
- Sun angle & Shadowing
- Season
- Atmospheric conditions

- Stereo or mono
- Colour or B&W
- Image preprocessing

*factors over which there is no or limited user control*
Radiometric Quality

• Image quality / interpretability can vary dramatically
• Images taken the same day of April from the same orbit

Luzern (CH)  Greek village (Nisyros)
Radiometric Quality

• Role of shadows and saturation (bright walls)
Image feature variation - *Ikonos* GEO 1m pan sharpened (RGB), Chinese military base in Hainan

Similar sun elevation / azimuth, quite similar sensor elevation

- 4 / 4 / 2001
- 9 / 4 / 2001
- 10 / 4 / 2001
- 30 / 4 / 2001
Radiometric Quality

Noise characteristics analyzed in areas:
- homogeneous (lake and sea surfaces)

<table>
<thead>
<tr>
<th>Image type</th>
<th>Mean std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAN-MSI</td>
<td>5.2</td>
</tr>
<tr>
<td>MSI</td>
<td>2.0</td>
</tr>
<tr>
<td>PAN</td>
<td>4.6</td>
</tr>
<tr>
<td>PAN-DRA</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Noise generally high since 11bit data represent 8-9 effective bits
Radiometric Quality

Noise characteristics analyzed in areas (PAN images):

- non-homogeneous (whole image excluding large homog. areas)

<table>
<thead>
<tr>
<th>GV range</th>
<th>0-127</th>
<th>128-255</th>
<th>256-383</th>
<th>384-511</th>
<th>512-639</th>
<th>640-767</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Image</td>
<td>2.6</td>
<td>3.1</td>
<td>4.1</td>
<td>4.7</td>
<td>5.6</td>
<td>6.6</td>
</tr>
<tr>
<td>with Noise Reduction</td>
<td>0.8</td>
<td>1</td>
<td>1.3</td>
<td>1.5</td>
<td>1.8</td>
<td>2.5</td>
</tr>
</tbody>
</table>

- Noise generally increases with intensity
- Adaptive filtering reduces noise by ca. factor 3
Radiometric Quality

Image Artifacts

Visible bands in epipolar images
Radiometric Quality

Image Artifacts

Left Stereo

• Staircase effect in left image
• Nonexisting white dotted lines

Right Stereo
Radiometric Quality

Spilling

- Strong reflection/saturation
- Spilling (blooming)
- Edge sharpening artifacts (overshoot, ringing)
- Spilling increased due to TDI use

Spilling in images over Geneva. Left and middle Ikonos, right Quickbird. The smaller the GSD, the larger the problems. The spill is always in the scan direction (forward in left image, reverse for the other two images). More and larger spills observed with Quickbird than Ikonos.
Radiometric Quality

Cause of Spilling

Bidec angle (Space Imaging, Eye on Quality, How collection geometry affects specular reflections, 2002)
Radiometric Quality

Image Artifacts

Left: grey level jumps between CCD subimages ; Right: bright horizontal and vertical stripes
Radiometric Quality

Image Artifacts
Pan-Sharpened Ikonos

Ghosting of moving object due to the 0.5 s time difference between acquisition of PAN and MSI
Preprocessing

Aim: Noise reduction, contrast & edge enhancement

Methods:
1. linear reduction from 11 to 8-bit
   - Gaussian filtering
   - Wallis filter
2. Like 1 but after Gaussian filtering
   - unbiased anisotropic diffusion
3. adaptive noise reduction (2 methods)
   - Wallis filtering
   - reduction to 8-bit (histogram equalisation or normalisation)
Preprocessing - Noise reduction, contrast & edge enhancement

Original

Preprocessed 2

Preprocessed 3

Original, contrast enhanced
Edge preserving noise reduction with adaptive fuzzy filtering (right).
Small details are kept and edges are in addition sharpened (Pateraki, 2005).
Contrast enhancement with Wallis filter. Left before, right after filtering (Pateraki, 2005).
Reduction to 8-bit. Left with linear transform, middle histogram equalization, right histogram normalization (Pateraki, 2005).