

## 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



11bit histogram Nadir PAN (Luzern) - with DRA



D R A stretches the grey values (GVs) to cover more uniformly the 11 bit range.

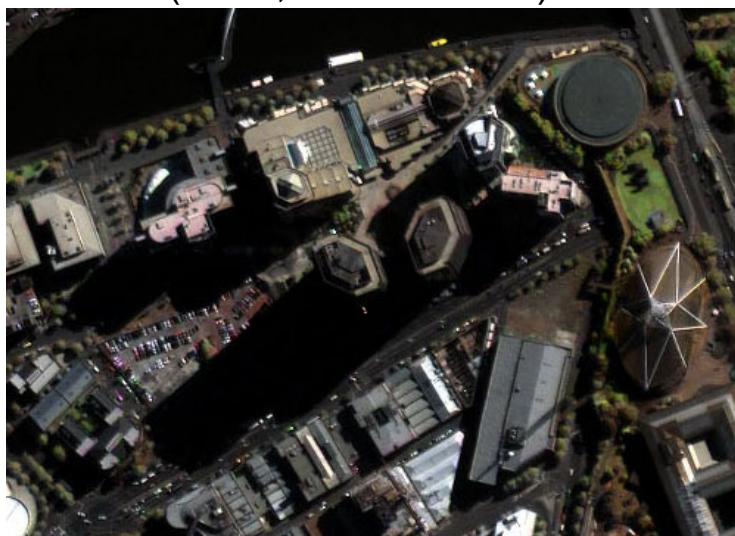
Result : Absolute radiometric accuracy is destroyed + leads to combination of GV's that are not frequently occupied. Better methods of contrast stretch exist.

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

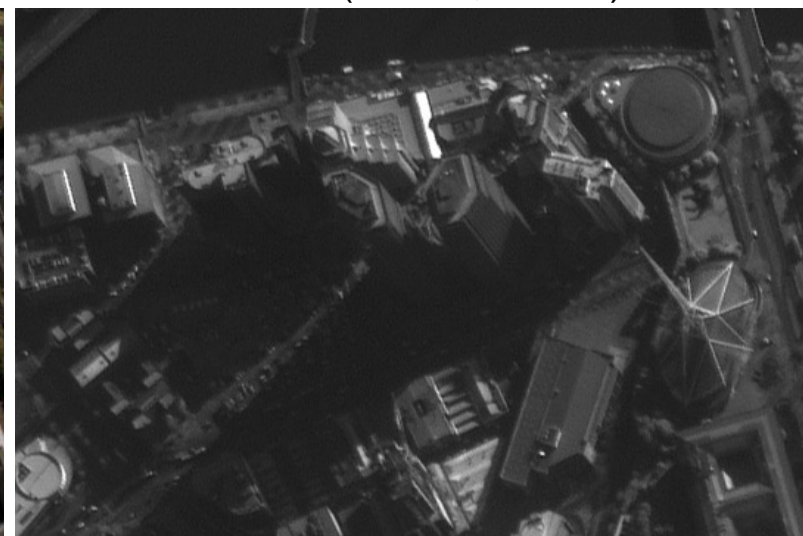
## Radiometric Quality

### 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)

Image type	Mean std. dev.
<b>PAN-MSI</b>	<b>5.2</b>
<b>MSI</b>	<b>2.0</b>
<b>PAN</b>	<b>4.6</b>
<b>PAN-DRA</b>	<b>5.0</b>

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)

GV range	0-127	128-255	256-383	384-511	512-639	640-767
Raw Image	2.6	3.1	4.1	4.7	5.6	6.6
with Noise Reduction	0.8	1	1.3	1.5	1.8	2.5

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

# Radiometric Quality

## Image Artifacts

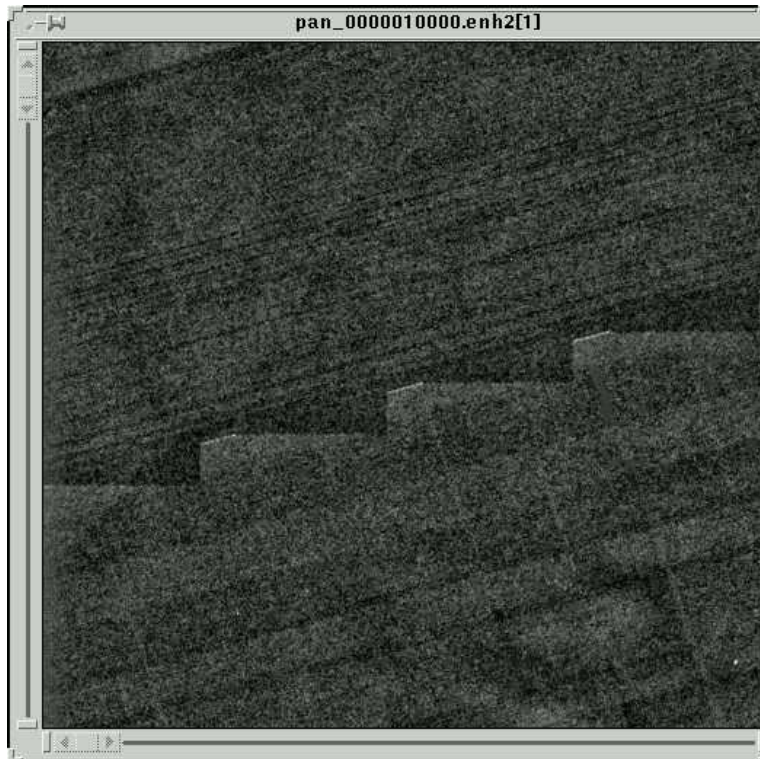


## Visible bands in epipolar images

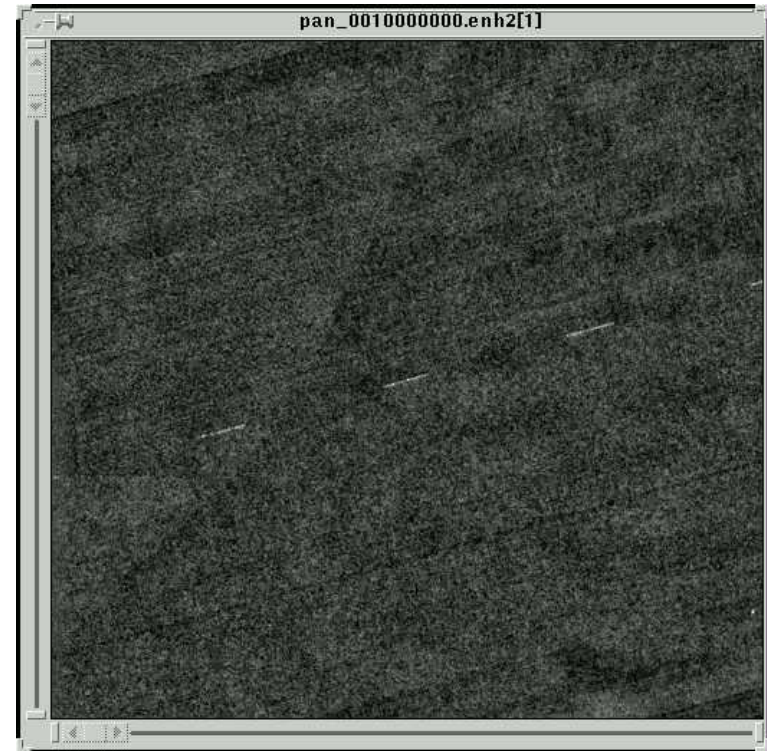
# Radiometric Quality

## Image Artifacts

Left Stereo



Right Stereo

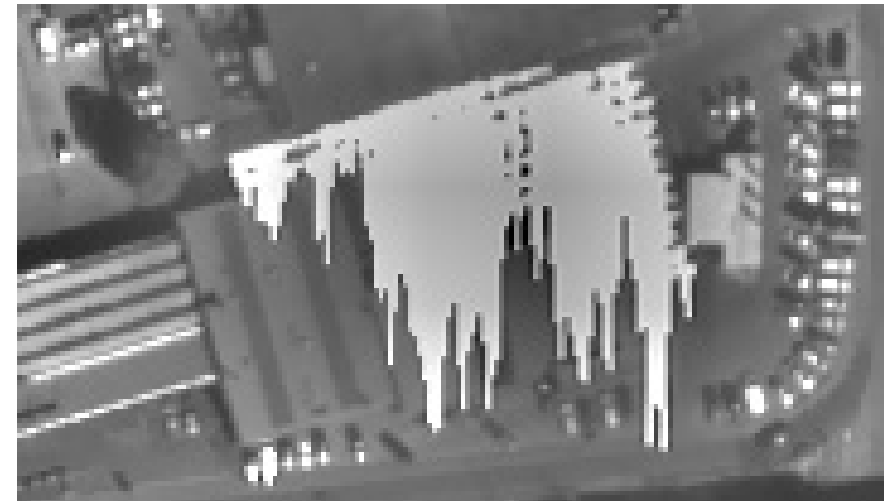
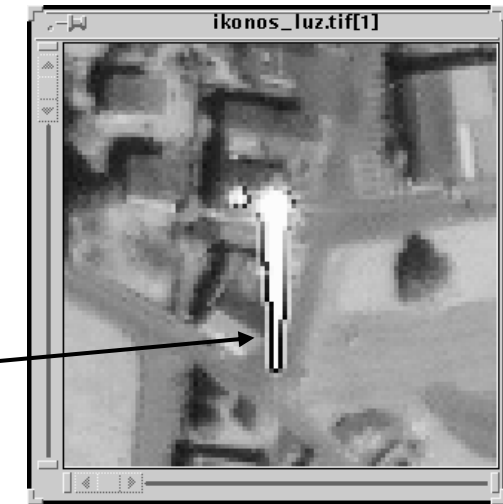


- Staircase effect in left image
- Nonexisting white dotted lines

## Radiometric Quality

### Spilling

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

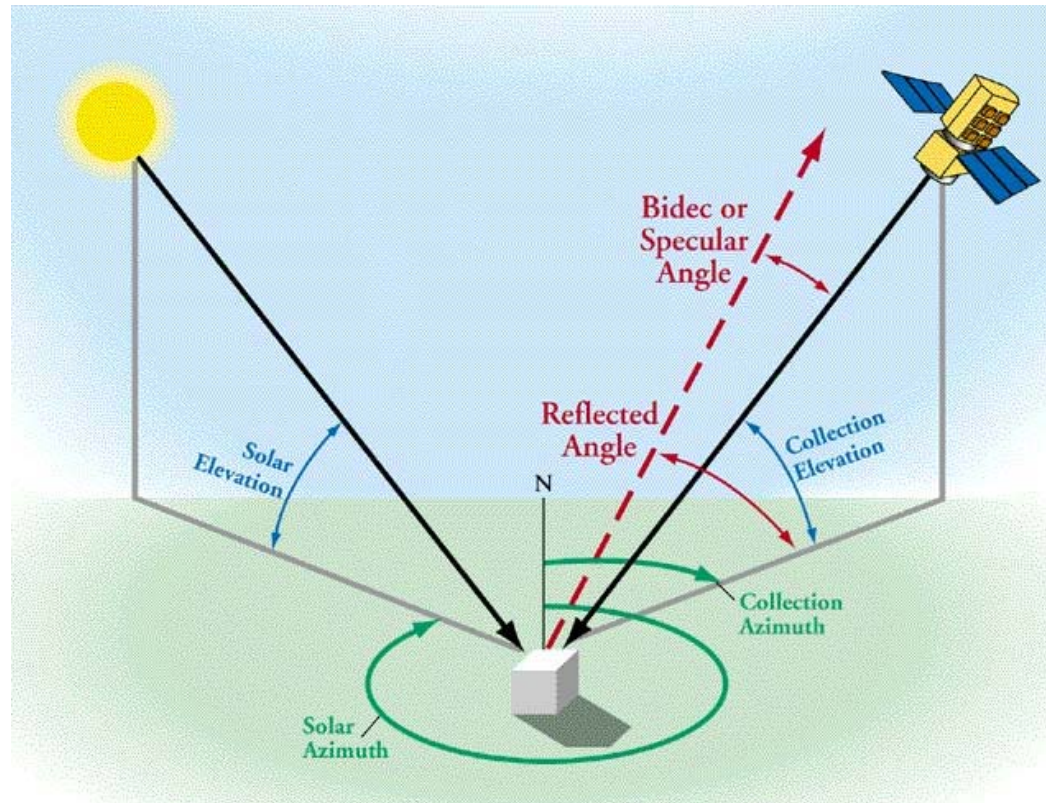


**Spilling in images over Geneva. Left and middle Ikonos, right Quickbird. The smaller the GSD, the larger the problems. The spill is always in the scan direction (forward in left image, reverse for the other two images). More and larger spills observed with Quickbird than Ikonos.**



# Radiometric Quality

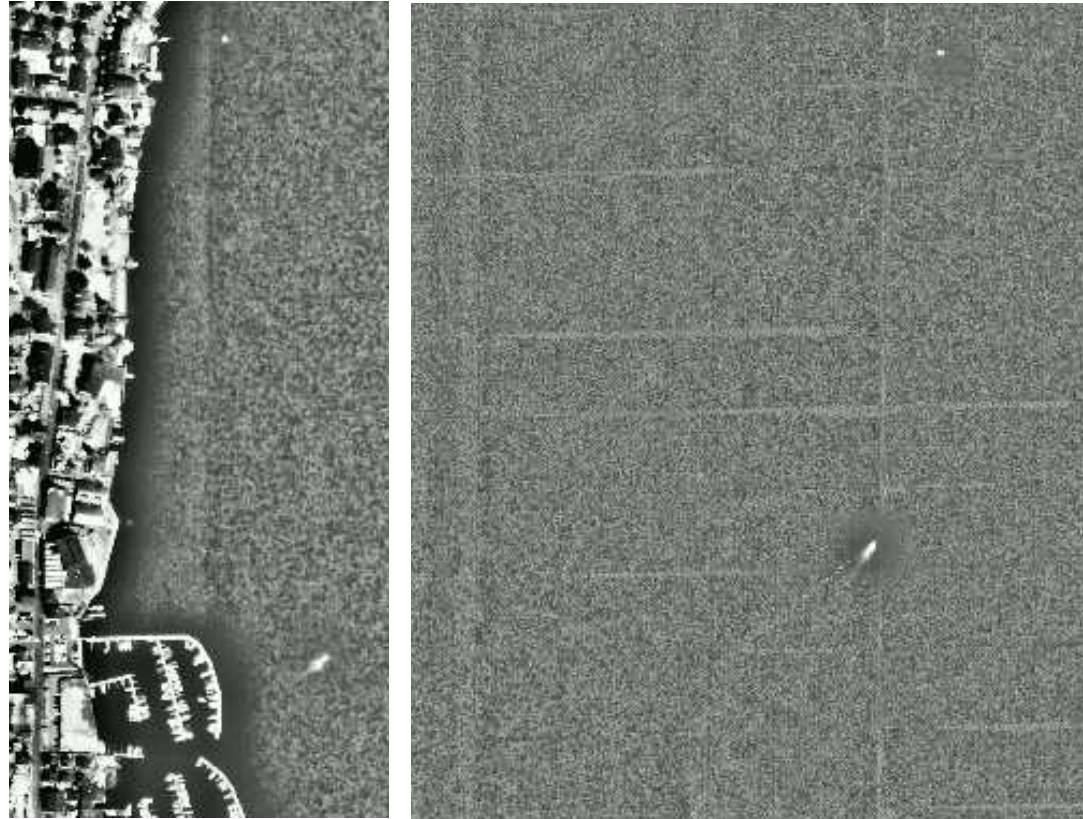
## Cause of Spilling



**Bidirectional 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



Original,  
contrast  
enhanced

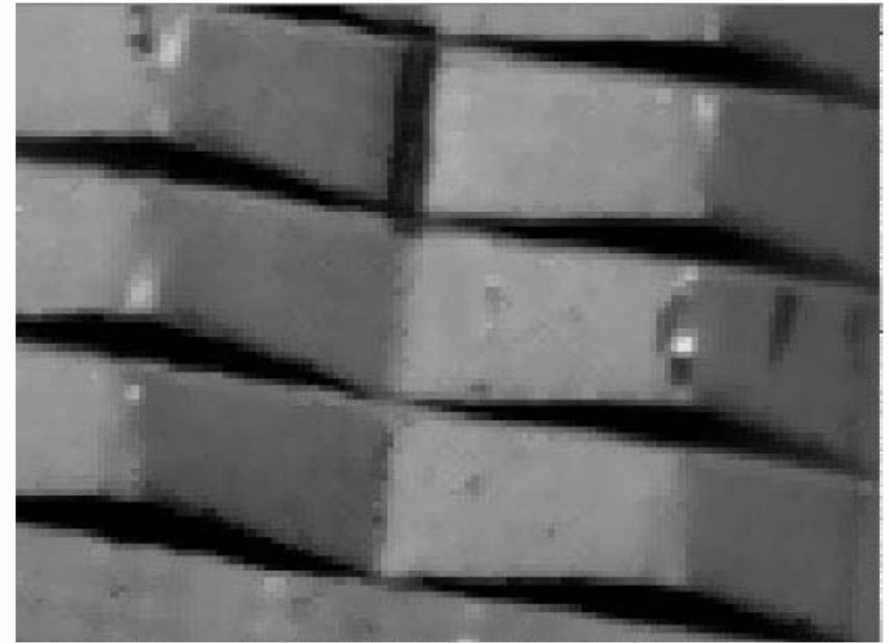
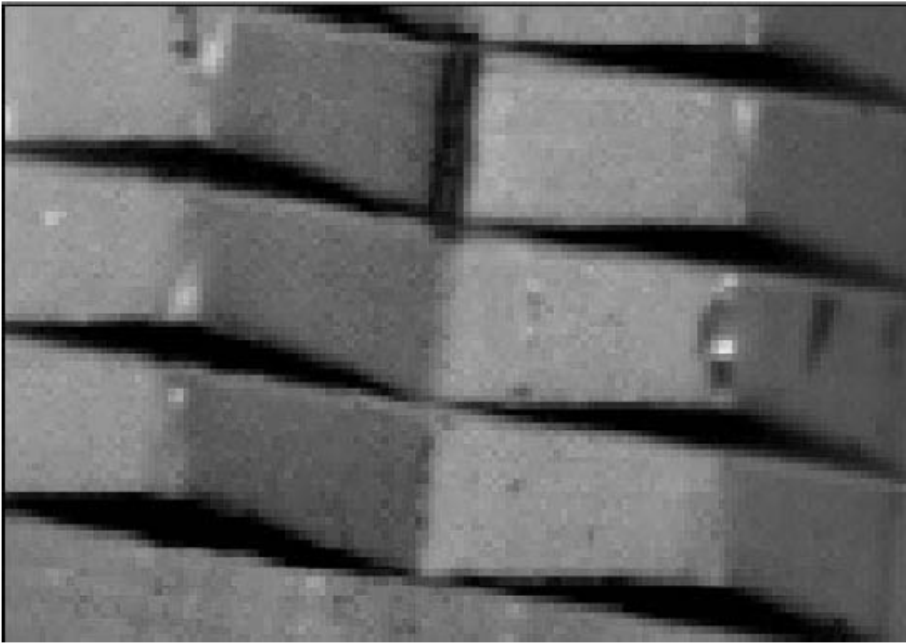


Preprocessed 2



Preprocessed 3





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).





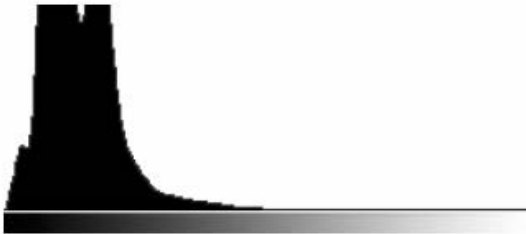
(a)



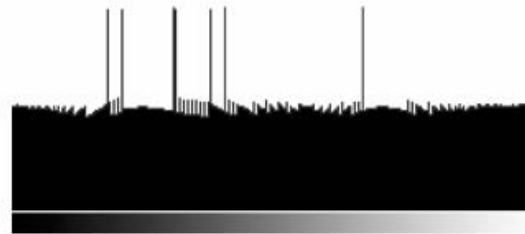
(b)



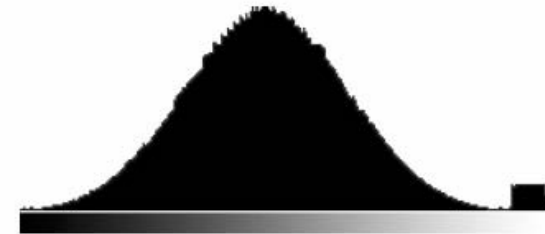
(c)



(d)



(e)



(f)

Reduction to 8-bit. Left with linear transform, middle histogram equalization, right histogram normalization (Pateraki, 2005).