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Remote Sensing and Satellite Imagery

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Types of Image Data Errors

Radiometric Errors

Errors in the measured brightness values of the pixels.

Geometric Errors

Errors between the actual image acquisition (sensor) coordinate data and ideal image coordinate data.

Note the following terminology:

BV: Brightness Value *or* **DN**: Digital Number

Sources of Radiometric Distortion

- Two broad types of radiometric distortion:
  - The **distribution of brightness** over an image in a given band can be different from that in the ground scene.
  - The **relative brightness** of a single pixel from band to band can be distorted.

- Both types can result from the presence of the **atmosphere** as a transmission medium through which radiation must travel from its source to the sensors, and can also be the result of **instrumentation effects**.

Correcting Instrumentation Errors

- Common remote sensing radiometric errors caused by instrumentation effects:
  - Random bad pixels (shot noise)
  - Line drop-outs
  - Line striping

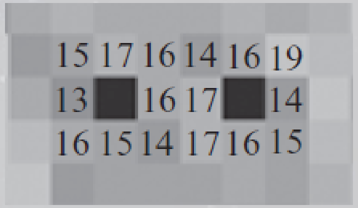
Random Bad Pixels (Shot Noise)

- Sometimes an individual detector does not record spectral data for an **individual pixel**.
  - When this occurs **randomly**, it is called a **bad pixel**.
  - When there are **numerous random** bad pixels found within the scene, it is called **shot noise** because it appears that the image was shot by a shotgun.
- Normally these bad pixels contain values of **0 or 255** (in 8-bit data) in one or more of the bands.
- Shot noise is identified and repaired using the following methodology:
  - First locate each bad pixel in the band k dataset: a simple **thresholding** algorithm makes a pass through the dataset and flags any pixel ($\boldsymbol{BV_{i,j,k}}$) having a brightness value of zero (while the surrounding pixels are not 0).
  - Once identified, it is then possible to evaluate the eight pixels surrounding the flagged pixel:

	col_{j-1}	col_j	col_{j+1}
row_{i-1}	BV_1	BV_2	BV_3
row_i	BV_8	BV_{ijk}	BV_4
row_{i+1}	BV_7	BV_6	BV_5

The mean of the eight surrounding pixels is computed and the value substitutes for $\boldsymbol{BV_{i,j,k}}$ in the corrected image:

$$BV_{i,j,k} = \text{Int}\left[\left(\sum_{i=1}^{8} BV_i\right)/8\right]$$



After Correction:

Line Drop-Outs

- If a detector in a linear array fails to function, this can result in an **entire line of data** with no spectral information.
- The bad line is commonly called a line drop-out and contains brightness values equal to zero.

- Methodology:
  - First locate each bad line in the image dataset: calculate the average ***BV*** per scan line for the entire scene. The average ***BV*** for each scan line is then compared with the scene average. Any scan line deviating from the average by more than a designated **threshold** value is identified as defective.
  - Once identified, it is then possible to collect the value for a pixel in the **preceding** line ($BV_{i-1,j,k}$) and the value for a pixel in the **succeeding** line ($BV_{i+1,j,k}$) and assign the output pixel ($BV_{i-1,j,k}$) in the drop-out line the **average** of these two brightness values:

$$BV_{i,j,k} = \mathrm{Int}\left(\frac{BV_{i-1,j,k} + BV_{i+1,j,k}}{2}\right)$$

89	89	96	94	98	108	111	110	94	80
104	108	93	92	97	94	86	81	75	83
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
131	143	107	101	122	127	88	86	87	90
122	155	147	115	145	155	101	91	92	95

89	89	96	94	98	108	111	110	94	80
104	108	93	92	97	94	86	81	75	83
118	**126**	**100**	**97**	**110**	**111**	**87**	**84**	**81**	**87**
131	143	107	101	122	127	88	86	87	90
122	155	147	115	145	155	101	91	92	95

Line Striping

- Sometimes a detector does not fail completely, but simply goes out of **radiometric adjustment**.

- For example, a detector might record spectral measurements that are almost uniformly 20 brightness values greater than the other detectors for the same band.

- The result would be an image with systematic, noticeable lines that are brighter than adjacent lines. This is referred to as ***n-line striping***. The correction is referred to as ***destriping.***

- The maladjusted line contains valuable information, but should be corrected to have approximately the same radiometric scale as the data collected by the properly calibrated detectors associated with the same band.

- To repair systematic n-line striping, it is first necessary to identify the miscalibrated scan lines in the scene.

- This is usually accomplished by computing a **histogram** of the values for each of the n detectors that collected data over the entire scene.

Line Striping

- If one detector's mean or median is significantly different from the others, it is probable that this detector is out of adjustment.
- Consequently, every line and pixel in the scene recorded by the maladjusted detector may require a bias (**additive or subtractive**) correction or a more severe gain (**multiplicative**) correction.
- This type of n-line striping correction
  - adjusts all the bad scan lines so that they have approximately the same radiometric scale as the correctly collected data.
  - improves the visual interpretability of the data (makes it look better).

Line Striping

- <u>Another Method:</u>
  - Correction of radiometric mismatches among the detectors can be carried out by adopting one detector as a **standard** and adjusting the brightness of all pixels recorded by each other detector so that their mean brightness and standard deviations match those of the standard detector.
  - That operation can be implemented by:

shbh l normal distribution eq.

$$y = \frac{\sigma_d}{\sigma_i} x + m_d - \frac{\sigma_d}{\sigma_i} m_i$$

Why this accomplishes the goal??

- x is the original brightness for a pixel
- y is its new (destriped) value
- m_d and σ_d are the reference values of mean brightness and standard deviation for the standard detector.
- m_i and σ_i are the values of mean brightness and standard deviation for the detector under consideration.

- Sometimes an *independent* reference mean and standard deviation is used.

Correcting Atmospheric Errors

- When an atmosphere is present there are two effects that must be taken into account: ***scattering*** and ***absorption*** by the particles.

- These lead to:
  - Fine detail in image data is obscured: *haze* in the imagery
  - The presence of the *absorption lines* superimposed by water vapour and other atmospheric constituents.

- Approximate techniques are available for atmospheric correction that depend directly on the measurements of the recorded image data.

- These are important when detailed data on the atmosphere, and particularly the water vapour content, are not available.

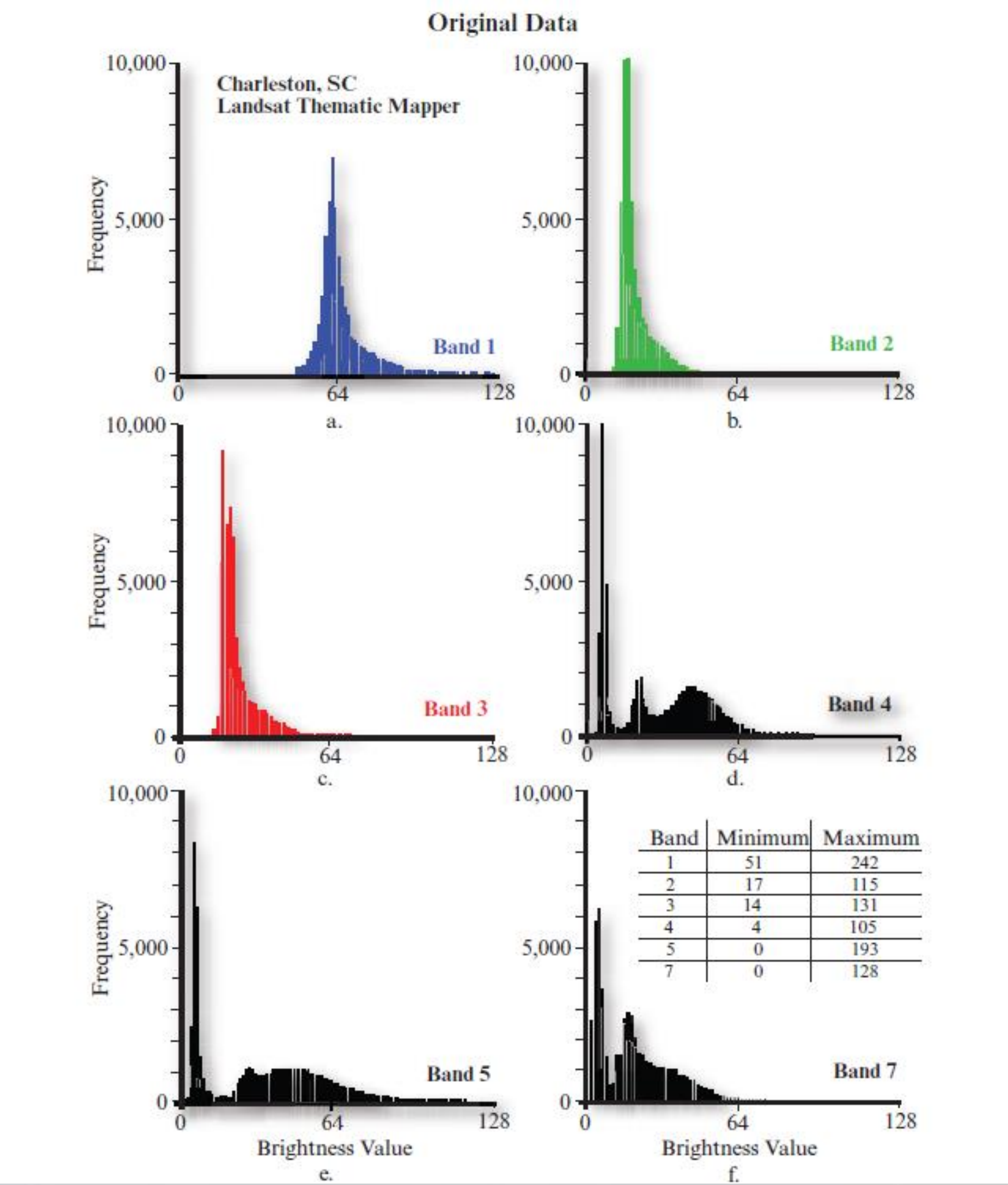
- The most common include:
  - Haze Removal by Dark Subtraction, also known as: Dark Object Subtraction

Haze Removal by Dark Subtraction

- It makes the assumption that each band of data for a given scene should contain some pixels at or close to **zero** brightness value but that atmospheric effects has added a **constant level** to each pixel in each band.

- Consequently, if histograms are taken of the bands (graphs of the number of pixels as a function of brightness value) the lowest significant occupied brightness value will be non-zero.

- The lowest occupied brightness value will be further from the origin for the *shorter wavelengths.*



Band	Minimum	Maximum
1	51	242
2	17	115
3	14	131
4	4	105
5	0	193
7	0	128

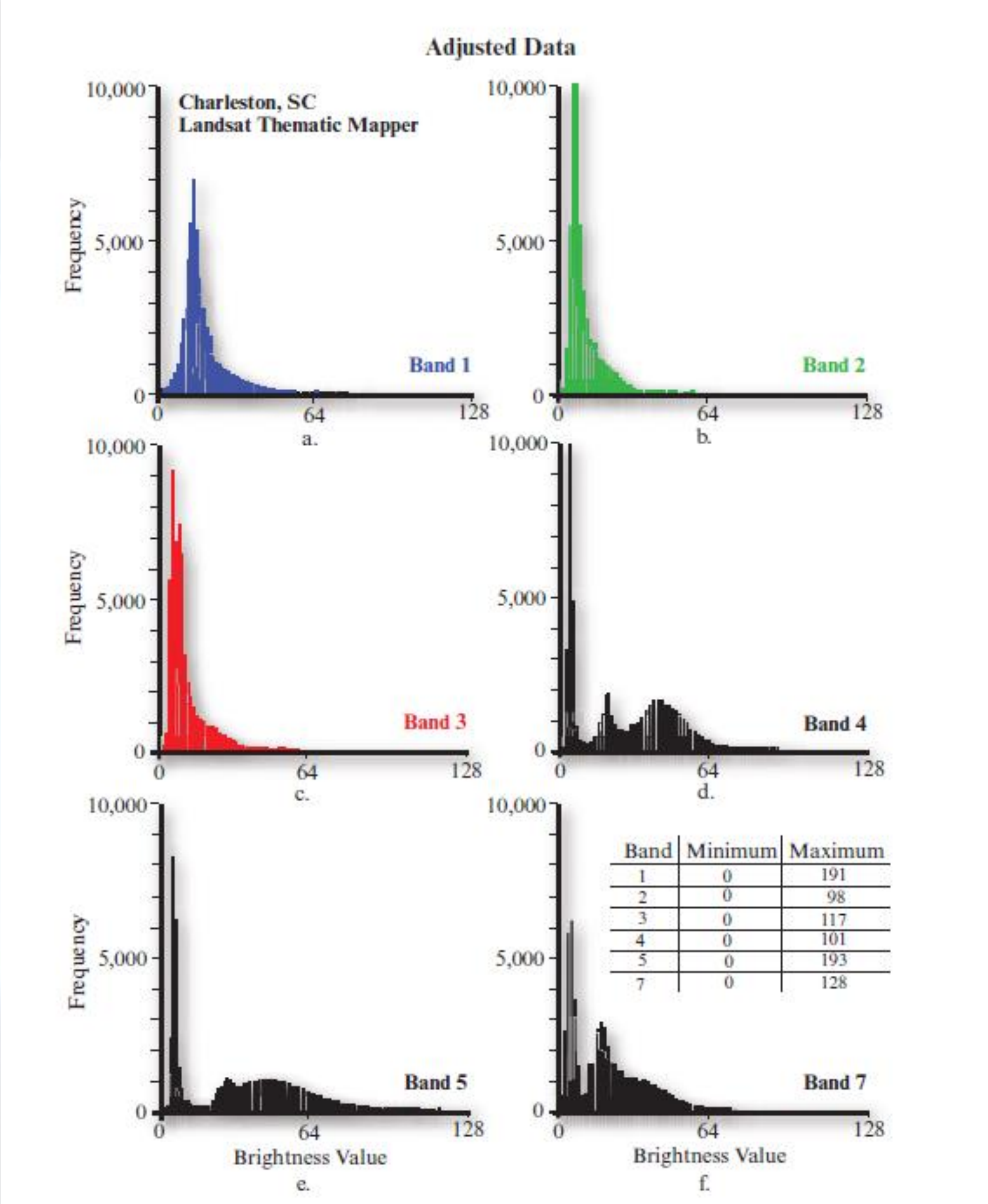
Haze Removal by Dark Subtraction

- If the histograms are shifted to the left so that zero values appear in the data, the effects of atmospheric scattering will be somewhat minimized.

- This simple algorithm is based on a **subtractive bias** established for each spectral band (the minimum *BV* in the histogram):

$$\text{output } BV_{i,j,k} = \text{input } BV_{i,j,k} - \text{bias}$$

- In the example the biases are chosen as follows:
  - Band1: bias=51
  - Band2: bias=17
  - Band3: bias=14
  - Band4: bias=4
  - Band5 and Band7: bias=0




Thank You