BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024
(Accredited with A+ Grade by NAAC in the Third Cycle)

Geometric & Radiometric Correction

Course: Digital image Processing
Programme: M.Tech Geoinformatics

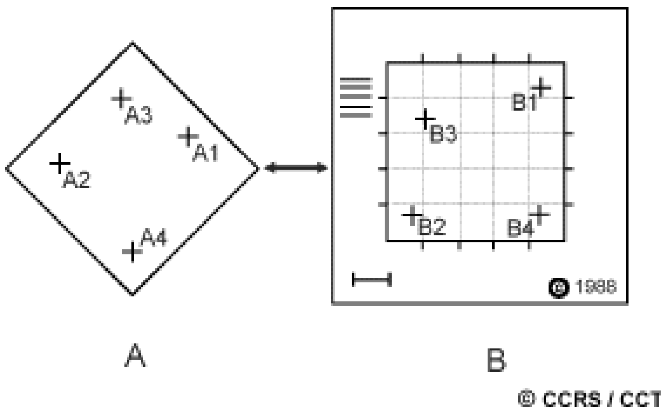
Dr. R. Jegankumar
Professor and Head, Geography, BDU

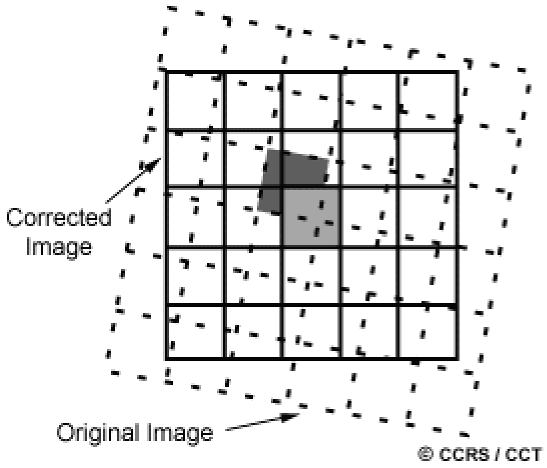
Geometric Correction

Skew caused by Earth rotation effects

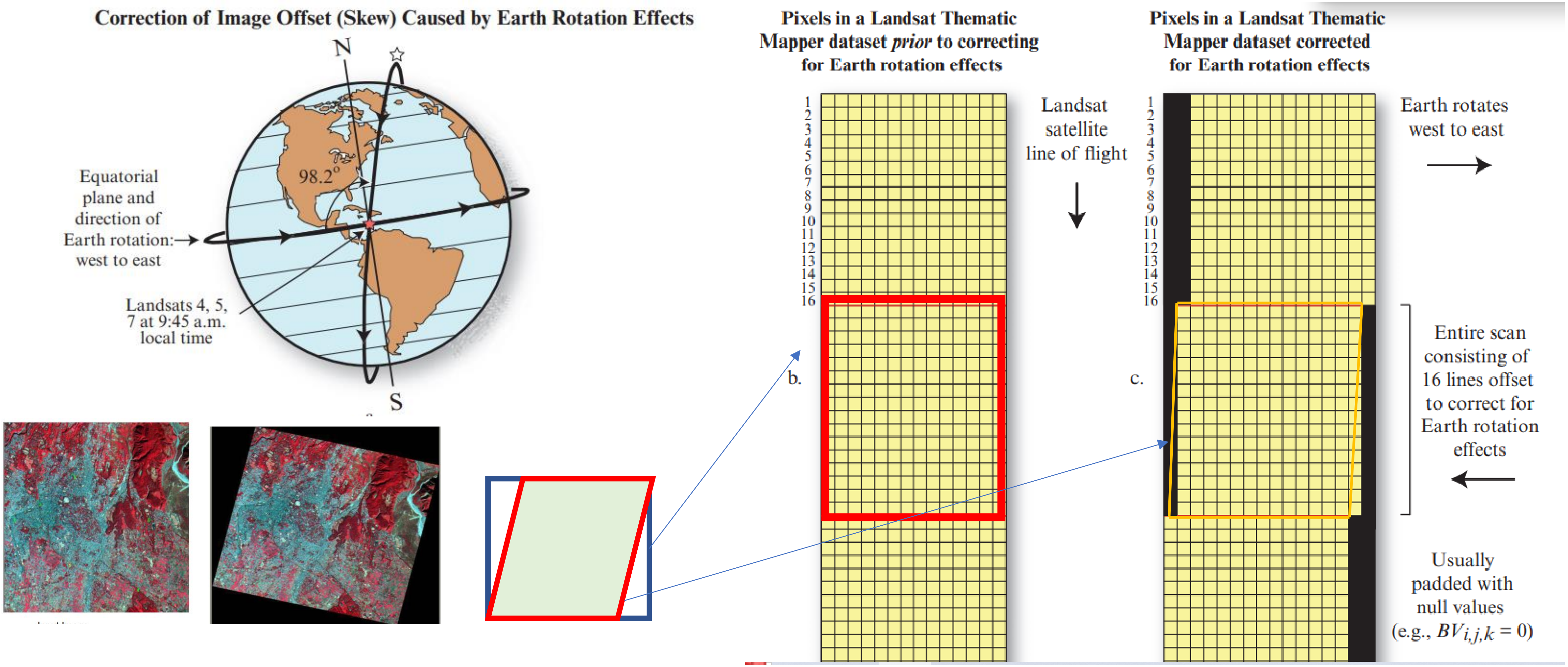
Scanning system–induced variation in nominal ground resolution cell size

External Geometric Errors





Skew caused by Earth rotation effects



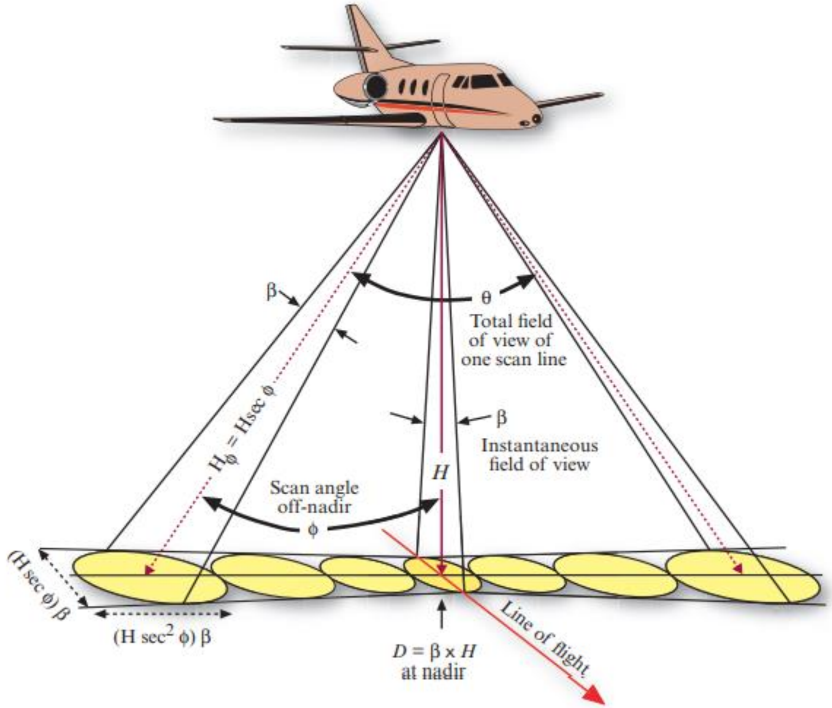
Scanning system–induced variation in nominal ground resolution cell size

A large amount of remote sensor data is acquired using scanning systems (e.g., Landsat 7, ASTER). Fortunately, an orbital multispectral scanning system scans through just a few degrees off-nadir as it collects data hundreds of kilometers above the Earth's surface (e.g., Landsat 7 data are collected at 705 km AGL).

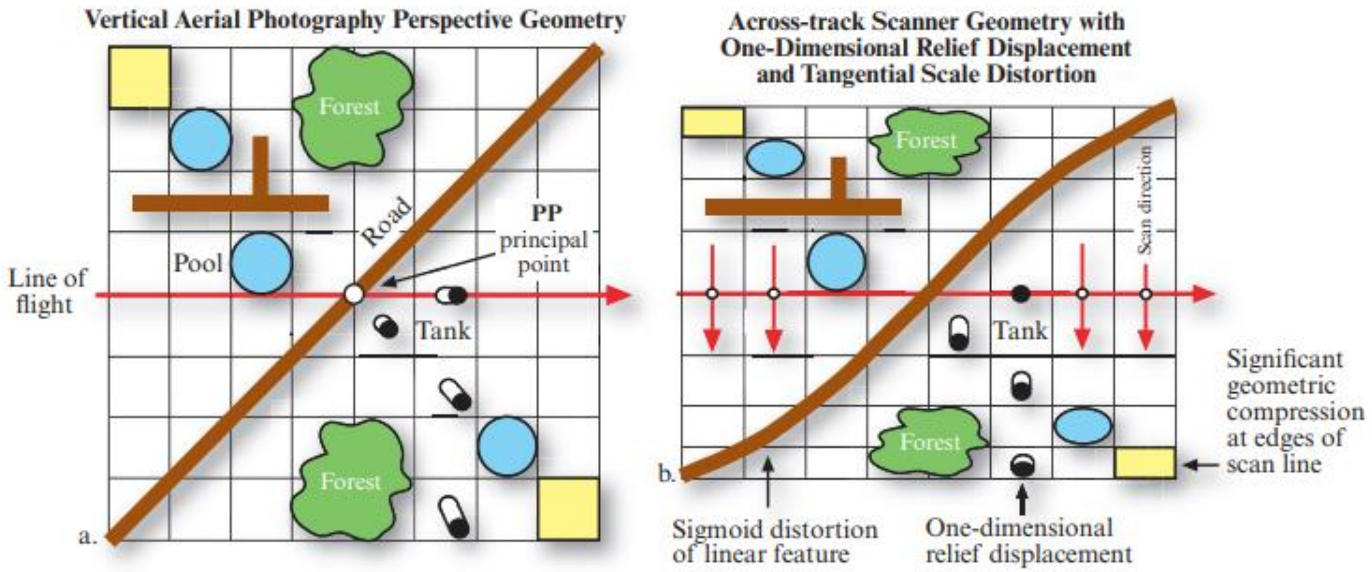
This configuration minimizes the amount of distortion introduced by the scanning system. Conversely, a suborbital multispectral scanning system may be operating just tens of kilometers AGL with a scan field of view of perhaps 70 degrees.

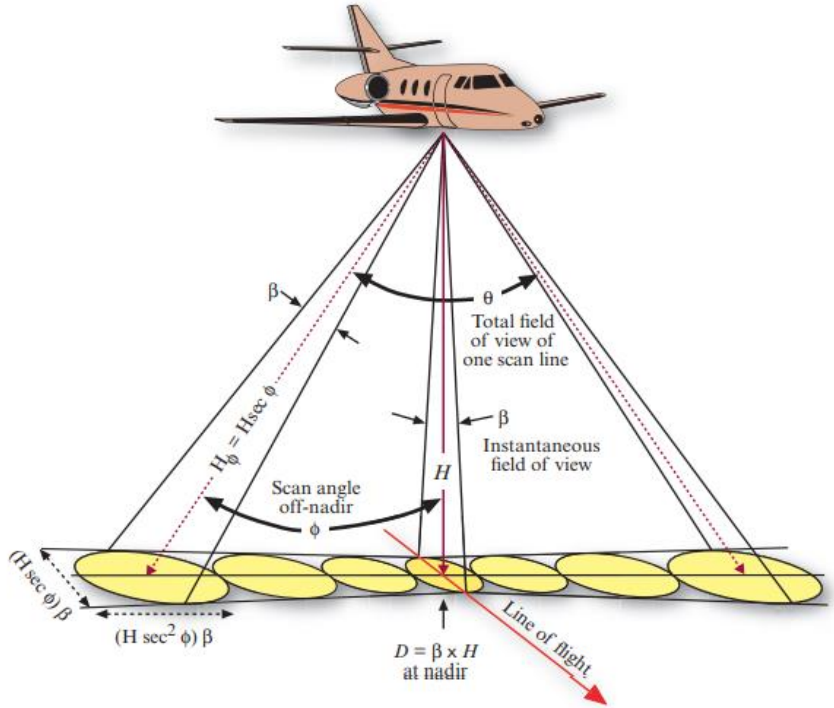
This introduces numerous types of geometric distortion that can be difficult to correct.

The ground swath width (gsw) is the length of the terrain strip remotely sensed by the system during one complete across-track sweep of the scanning mirror. It is a function of the total angular field of view of the sensor system, , and the altitude of the sensor system above ground level, H It is computed using the equation:



$$gsw = \tan\left(\frac{\theta}{2}\right) \times H \times 2 .$$





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John R. Jensen (2017) INTRODUCTORY DIGITAL IMAGE PROCESSING,): A Remote Sensing Perspective , 4th Edn
Pearson Education, U.S.A

External Geometric Errors

External geometric errors are usually introduced by phenomena that vary in nature through space and time. The most important external variables that can cause geometric error in remote sensor data are random movements by the aircraft (or spacecraft) at the exact time of data collection, which usually involve:

- ❖ altitude changes, and/or
- ❖ attitude changes (roll, pitch, and yaw)

External Geometric Errors

Altitude Changes

A remote sensing system is ideally flown at a constant altitude above ground level (AGL) resulting in imagery with a uniform scale all along the flightline.

For example, a frame camera with a 12-in. focal length lens flown at 20,000 ft. A GL will yield 1:20,000-scale imagery. If the aircraft or spacecraft gradually changes its altitude along a flightline, then the scale of the imagery will change (Figure 7-4a). Increasing the altitude will result in smaller-scale imagery (e.g., 1:25,000-scale). Decreasing the altitude of the sensor system will result in larger-scale imagery (e.g., 1:15,000). The same relationship holds true for digital remote sensing systems that collect imagery on a pixel by pixel basis.

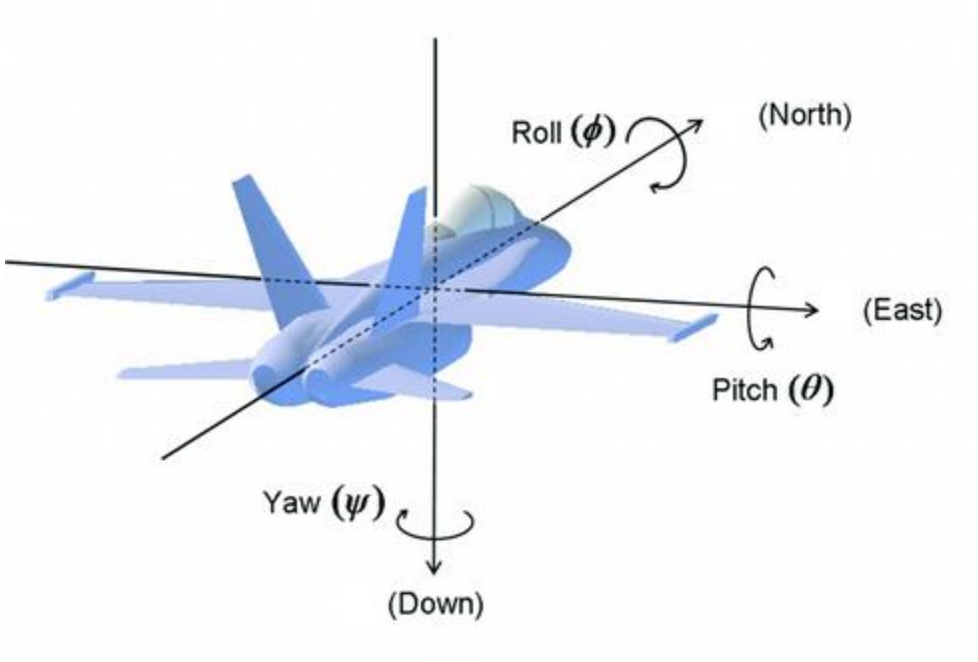
External Geometric Errors

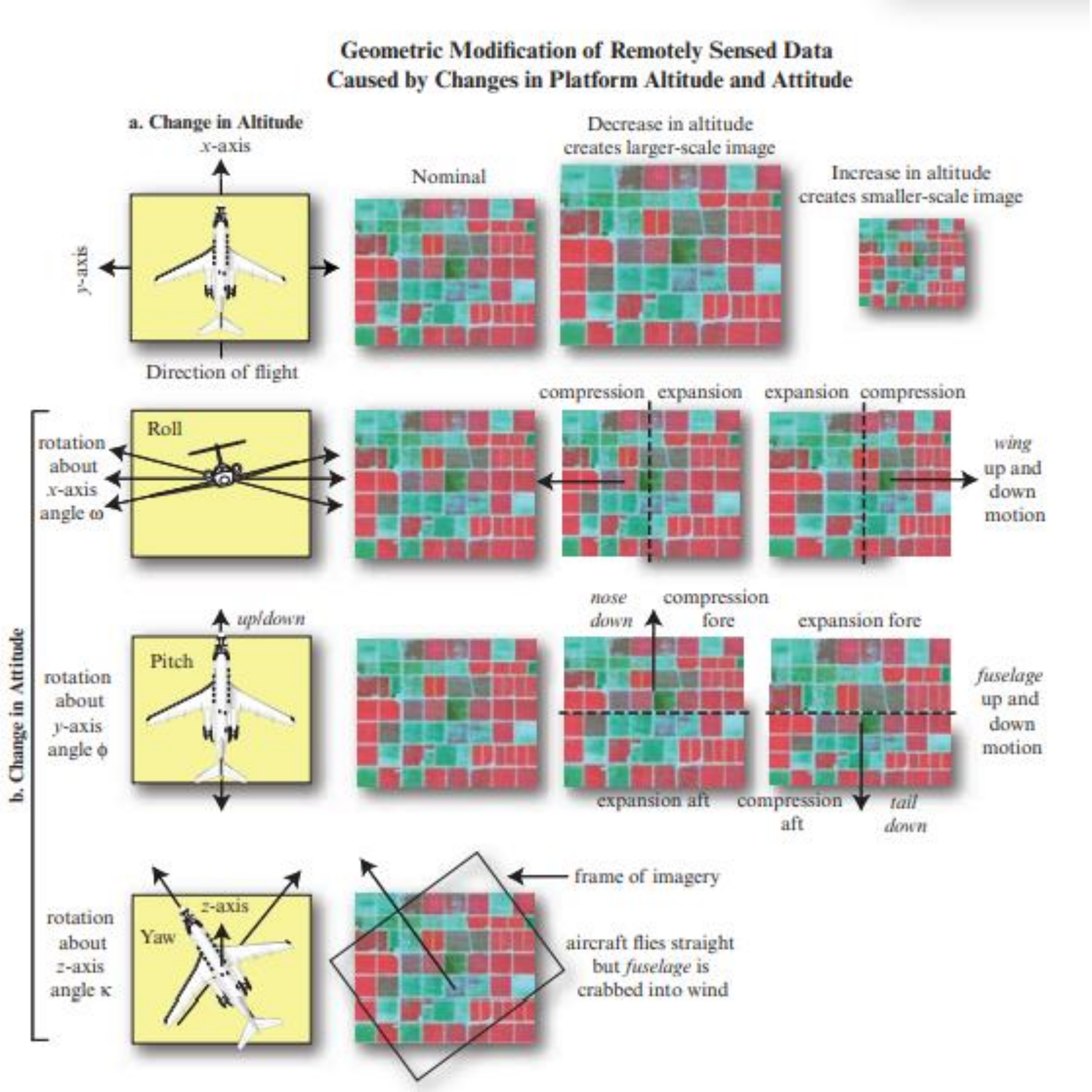
Attitude changes (Roll, Pitch & Yaw)

Satellite platforms are usually stable because they are not buffeted by atmospheric turbulence or wind. Conversely, aircraft flying at suborbital altitudes must continuously contend with atmospheric downdrafts, updrafts, head-winds, tail-winds, and cross-winds when collecting remote sensor data. Even when the remote sensing platform maintains a constant altitude AGL, it may rotate randomly about three separate axes that are commonly referred to as Roll, Pitch, and Yaw

External Geometric Errors

Attitude changes (Roll, Pitch & Yaw)

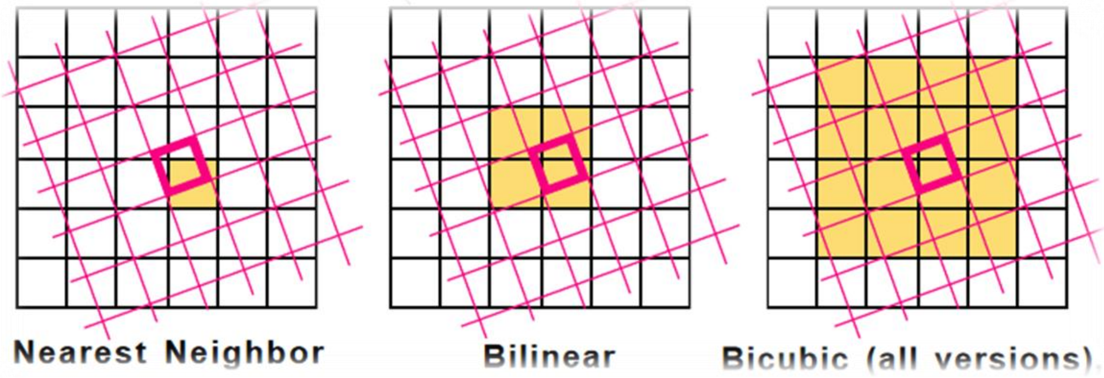




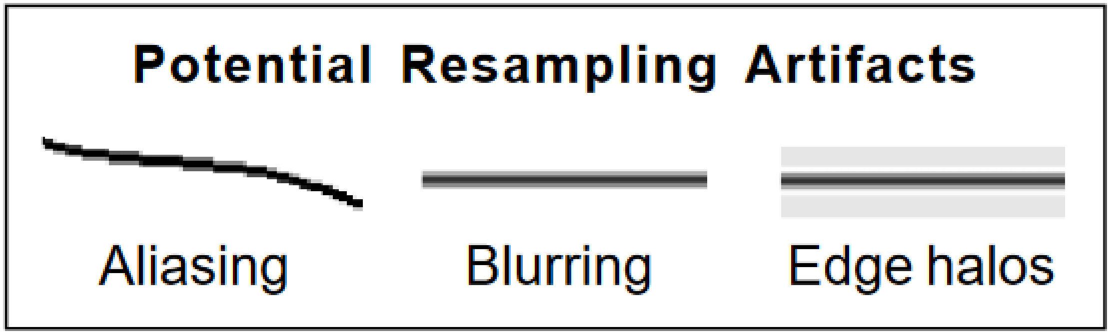
Resampling Methods

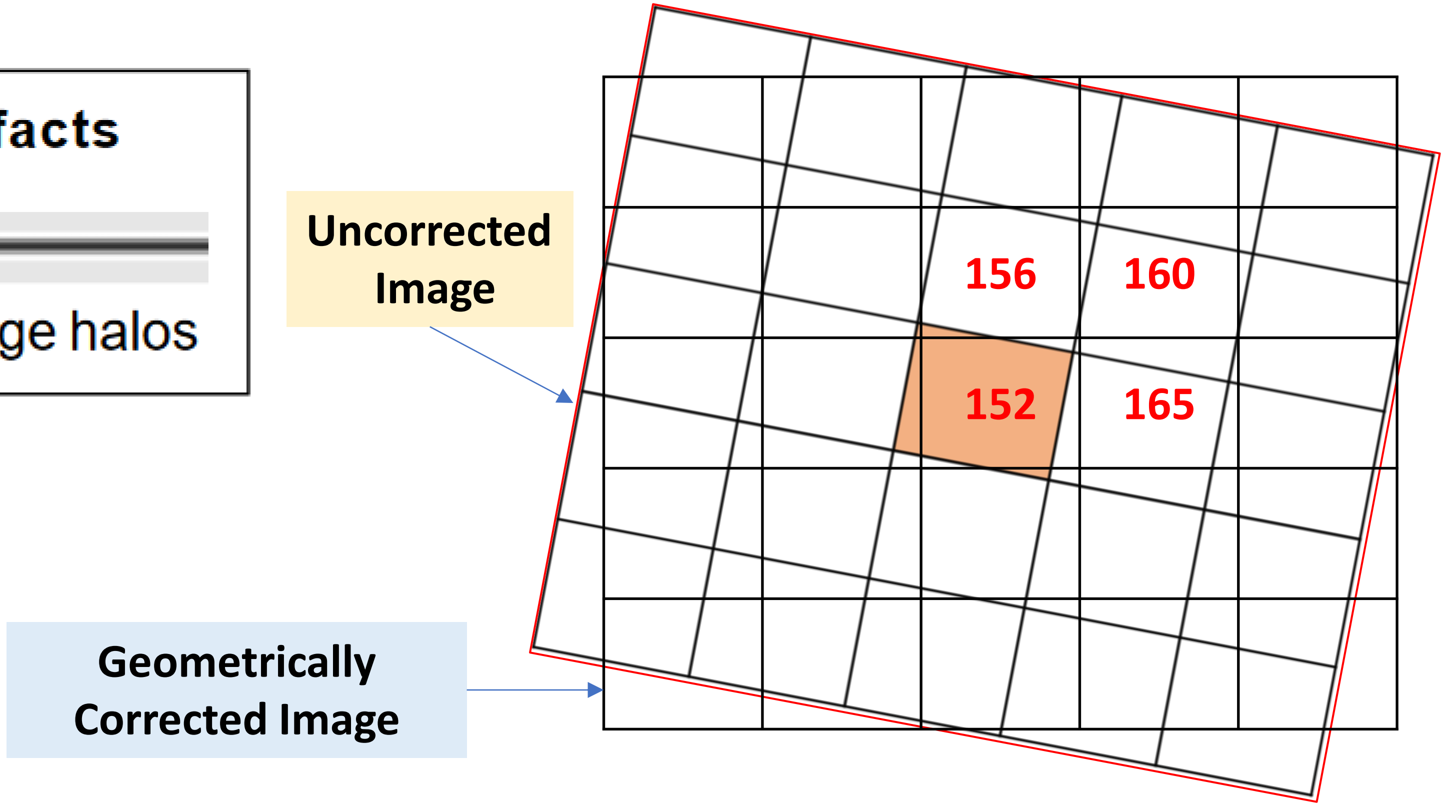
Rescaling a raster object or reprojecting it to a different coordinate reference system involves creating a new raster cell grid on a different alignment than the original raster.

A value for each cell in the new raster object must be computed by sampling or interpolating over some neighborhood of cells in the corresponding position in the original raster object.



Resampling inevitably introduces some visual artifacts in the resampled image. The main types of artifacts are most easily seen at sharp edges, and include aliasing **(jagged edges), blur- ring, and edge halos**



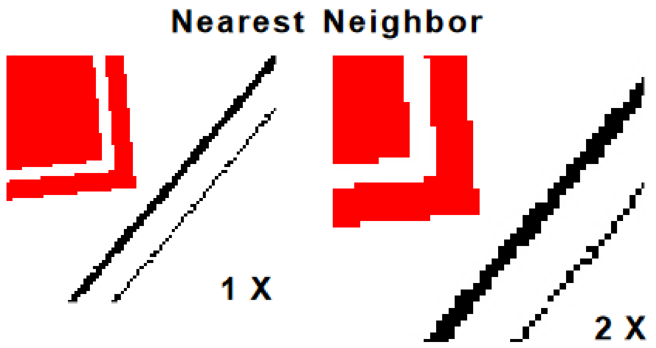


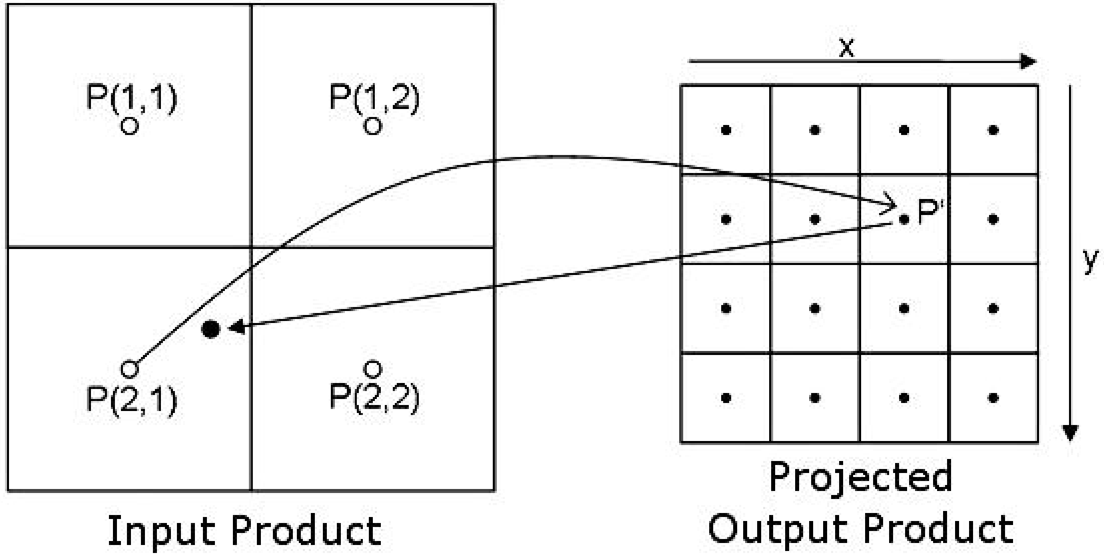
Nearest Neighbor

Each cell value in the resampled raster is determined by simply copying the value from the closest input cell.

This method is most suitable for reprojecting a raster object (without a change in cell size) when preserving the original cell values for later quantitative analysis is important.

When resampling involves rotation, the nearest neighbor method introduces severe aliasing of sharp edges.





https://seadas.gsfc.nasa.gov/help8.2.0/general/overview/ResamplingMethods.html.

ADVANTAGES:

- Output values are the original input values. Other methods of resampling tend to average surrounding values.
- This may be an important consideration when discriminating between vegetation types or locating boundaries.
- Since original data are retained, this method is recommended before classification. Easy to compute and therefore fastest to use

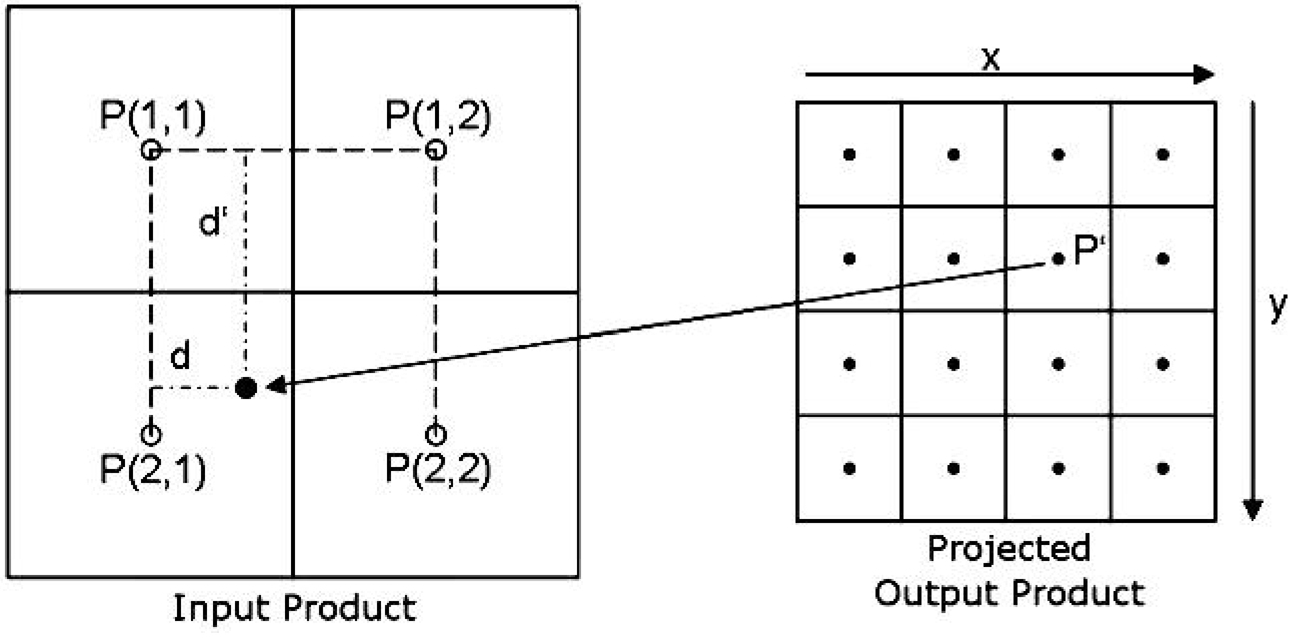
DISADVANTAGES:

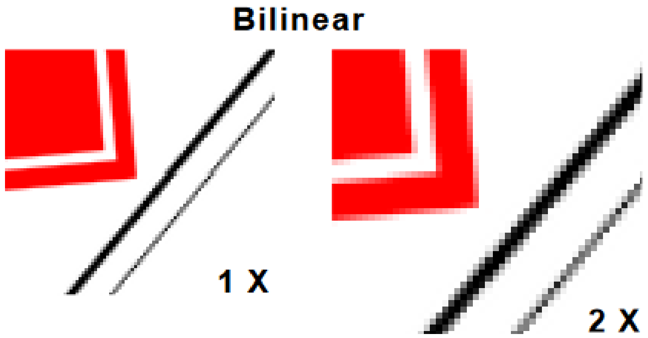
- Produces a choppy, "stair-stepped" effect. The image has a rough appearance relative to the original unrectified data.
- Data values may be lost, while other values may be duplicated

Bilinear Interpolation

First-order or bilinear interpolation assigns output pixel values by interpolating brightness values in two orthogonal directions in the input image. It basically fits a plane to the four pixel values nearest to the desired position (x ', y') in the input image and then computes a new brightness value based on the weighted distances to these points.

$$\text{Bilinear}_{BV_{wt}} = \frac{\sum_{k=1}^{4} \frac{Z_k}{D_k^2}}{\sum_{k=1}^{4} \frac{1}{D_k^2}},$$





https://seadas.gsfc.nasa.gov/help8.2.0/general/overview/ResamplingMethods.html.

https://www.microimages.com/documentation/TechGuides/77resampling.pdf

ADVANTAGES:

- Stair-step effect caused by the nearest neighbor approach is reduced. Image looks smooth.

DISADVANTAGES:

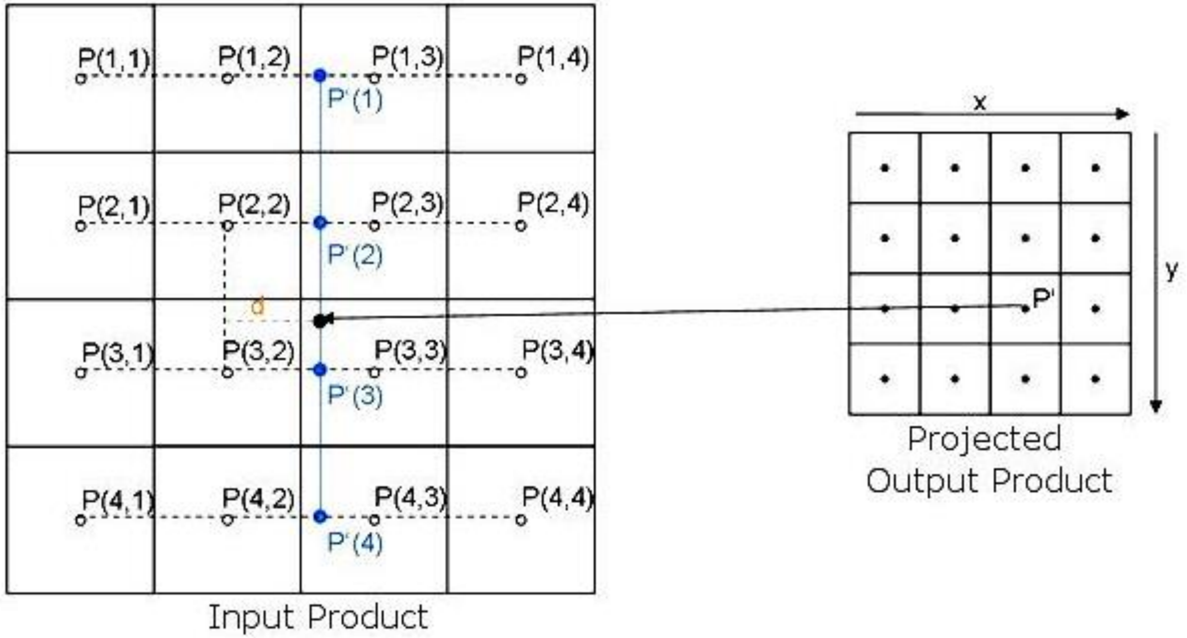
- Alters original data and reduces contrast by averaging neighboring values together is computationally more extensive than nearest neighbor
- New values are calculated which are not present in the input product

Cubic Convolution

Cubic Convolution: Resampling assigns values to output pixels in much the same manner as bilinear interpolation, except that the weighted values of sixteen input pixels surrounding the location of the desired pixel are used to determine the value of the output pixel

$$BV_{wt} = \frac{\sum_{k=1}^{16} \frac{Z_k}{D_k^2}}{\sum_{k=1}^{16} \frac{1}{D_k^2}}$$

where $\boldsymbol{Z_k}$ are the surrounding four data point values, and $\boldsymbol{D^2_k}$ are the distances squared from the point in question ($\boldsymbol{x'}$, $\boldsymbol{y'}$) to the these data points.



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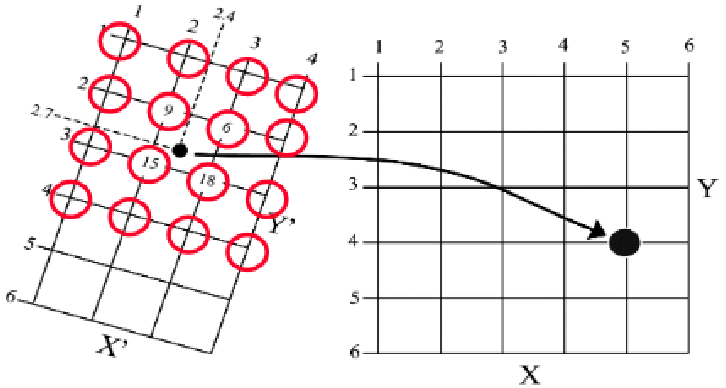
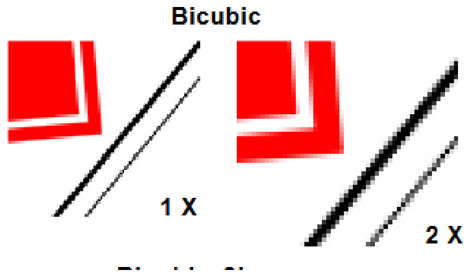


Original input image (a) Rectified output image (b)



ADVANTAGES:
Stair-step effect caused by the nearest neighbor approach is reduced. Image looks smooth.

DISADVANTAGES:
Alters original data and reduces contrast by averaging neighboring values together.

Is computationally more expensive than nearest neighbor or bilinear interpolation.

Geometric Errors

Internal geometric errors are generally introduced by the remote sensing system itself or in combination with Earth rotation or curvature characteristics. These distortions are often systematic (**predictable**) and may be identified and then corrected using prelaunch or inflight platform ephemeris (*i.e., information about the geometric characteristics of the sensor system and the Earth at the time of data acquisition*). Geometric distortions in imagery that can sometimes be corrected through analysis of sensor characteristics and ephemeris data

- ✓ Skew caused by Earth rotation effects,
- ✓ Scanning system–induced variation in nominal ground resolution cell size
- ✓ Scanning system one-dimensional relief displacement
- ✓ Scanning system tangential scale distortion.

Radiometric Correction

- ❖random bad pixels (shot noise),
- ❖line-start/stop problems,
- ❖line or column drop-outs,
- ❖partial line or column drop-outs, and
- ❖line or column striping.

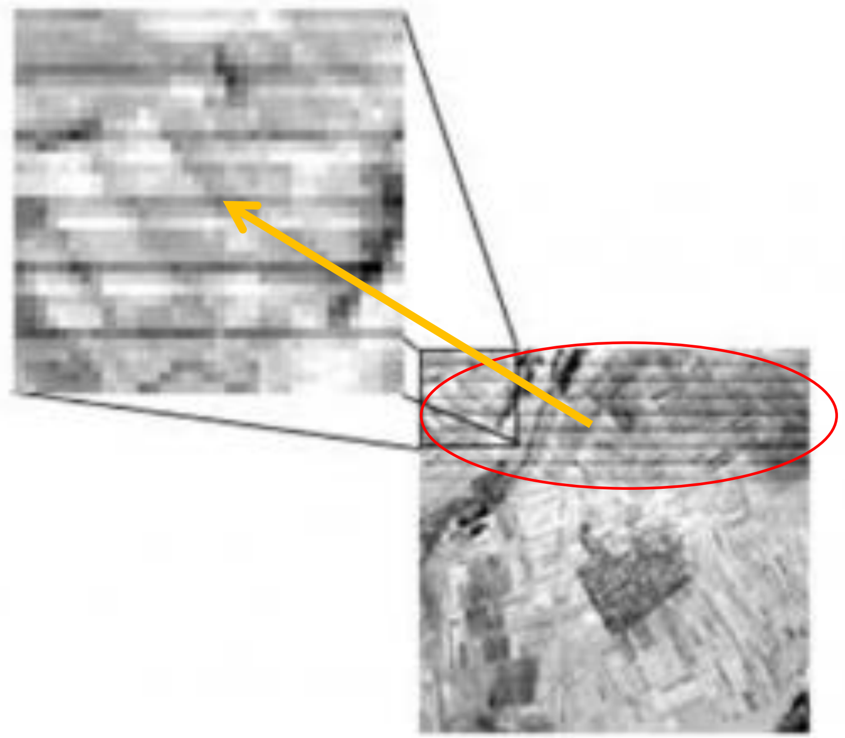


Image Source: http://www.eo4geo.eu/training/preprocessing-of-eo-data/

Radiometric errors

Radiometric errors are caused by -
detector imbalance and atmospheric deficiencies.

Radiometric error in remotely sensed data may be introduced by the sensor system itself when the ***individual detectors do not function properly or are improperly calibrated.*** Several of the more common remote sensing system– induced radiometric errors are:

- ❖random bad pixels (shot noise),
- ❖line-start/stop problems,
- ❖line or column drop-outs,
- ❖partial line or column drop-outs, and
- ❖line or column striping.

Random Bad Pixels (Shot Noise)

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**

Once identified, it is then possible to evaluate the eight pixels surrounding the flagged pixel, as shown below

	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

Line or Column Drop-Outs

Line or Column Drop-Outs An entire line containing no spectral information may be produced if an individual detector in a scanning system (e.g., Landsat 7 ETM +) fails to function properly.

If a detector in a linear array (e.g., SPO 5, Geo-Eye-1, WorldView-2) fails to function, this can result in an entire column of data with no spectral information. The ***bad line or column*** is commonly called a **line or column drop-out**

Replacement by either the preceding or the succeeding line

BVI,J=BVI,J-1 OR BVI,J=BVI,J+1 BVI,J =missing pixel value of pixel I scan line J

Averaging of the neighbouring pixel values ***BVI,J=(BVI,J-1 + BVI,J+1)/2***

Replacing the line with other highly correlated band.

Partial line or column drop-outs

An individual detector will function perfectly along a scan line and then for some unknown reason it will not function properly for n columns.

Then sometimes the detector functions properly again for the remainder of the scan line. ***The result is a portion of a scan line with no data.*** This is commonly referred to as a partial line or partial column drop-out problem.

If the portion of the image with the drop-out problem is particularly important, then the analyst must manually correct the problem pixel by pixel. ***The mean of the brightness values above and below each bad pixel and place the average in the bad pixel location***

Line-Start Problems

Line-Start Problems Occasionally, scanning systems fail to collect data at the beginning of a scan line, or they place the pixel data at inappropriate locations along the scan line. For example, all of the pixels in a scan line might be ***systematically shifted just one pixel to the right***. This is called a line-start problem. It can be corrected using a ***simple horizontal adjustment.***

N -Line Striping

N -Line Striping Sometimes a detector does not fail completely, but simply goes out of radiometric adjustment. For example, a detector might record spectral measurements over a dark, deep body of water 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

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Thank You