

Swath and line misalignment

Anomaly occurs on <i>LANDSAT 5 - 7</i>	Anomaly status <i>OPEN</i>	Related QUISS test: <i>Swath and lines alignment</i>	Anomaly slip <i>02</i> Version <i>01</i> 23/04/2003
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Related QUISS test

“Swath and line alignment” test checks the possible misalignments of the lines (or part of the lines) at the junction between two successive swaths.

LANDSAT TM and ETM+ instruments use a scanner that acquire 8,16, or 32 lines at time depending on the band being acquired. The purpose of this test is to check the continuity between the last line and the first line of the successive swath.

For each tested band, the algorithm consists in performing a correlation between the “upper line” (the last line of the swath n) and the “lower line” (the first line of the swath n+1) for various horizontal offsets of the upper line regarding the lower line. The offset with the maximum correlation helps detecting a possible displacement between parts along the swath junction.

The station operator running the «supervision mode» visually checks every corrupted area where the application automatically detected a swath or line misalignment. Any detected defects must be validated. Over five (5) validated defects, the test result will be set as “Failed”.

Anomalies description

The swath and line anomaly occurs on all the bands because the swath and line realignment process is based on a same mirror scan correction data (MSCD) applied on any bands. This section describes the following anomalies related to swath and line:

- Large swath shifts;
- small swath shifts;
- line displacements.

Large swath shifts

An important swath shift is observed. It can be located at the beginning, the middle or the end of the swath. On the figure below, we observe a swath shift of about 35 pixels.

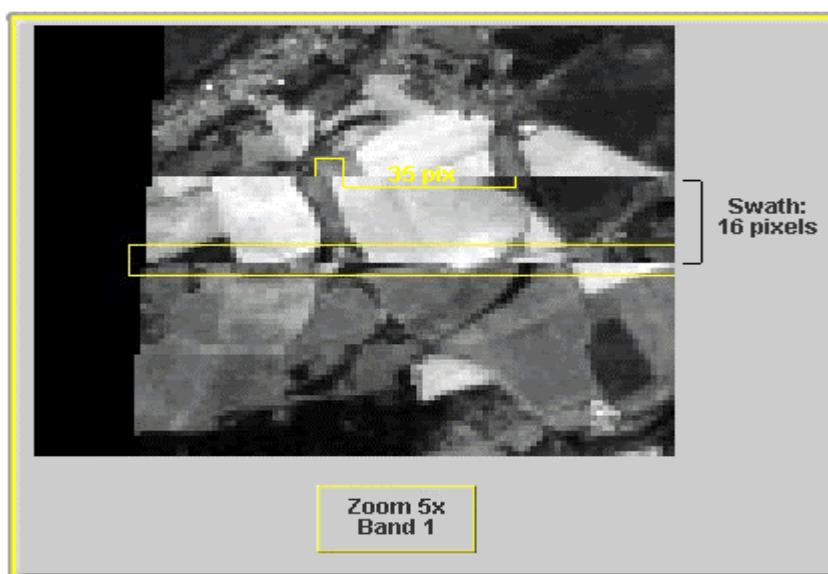


fig. 1 - Large swath shift.

The shift depends on the scan mirror direction (forward or reverse scan direction). The figure below shows three consecutive shifted swaths. Two occurring in the forward mirror scan direction and one in the reverse mirror scan direction.

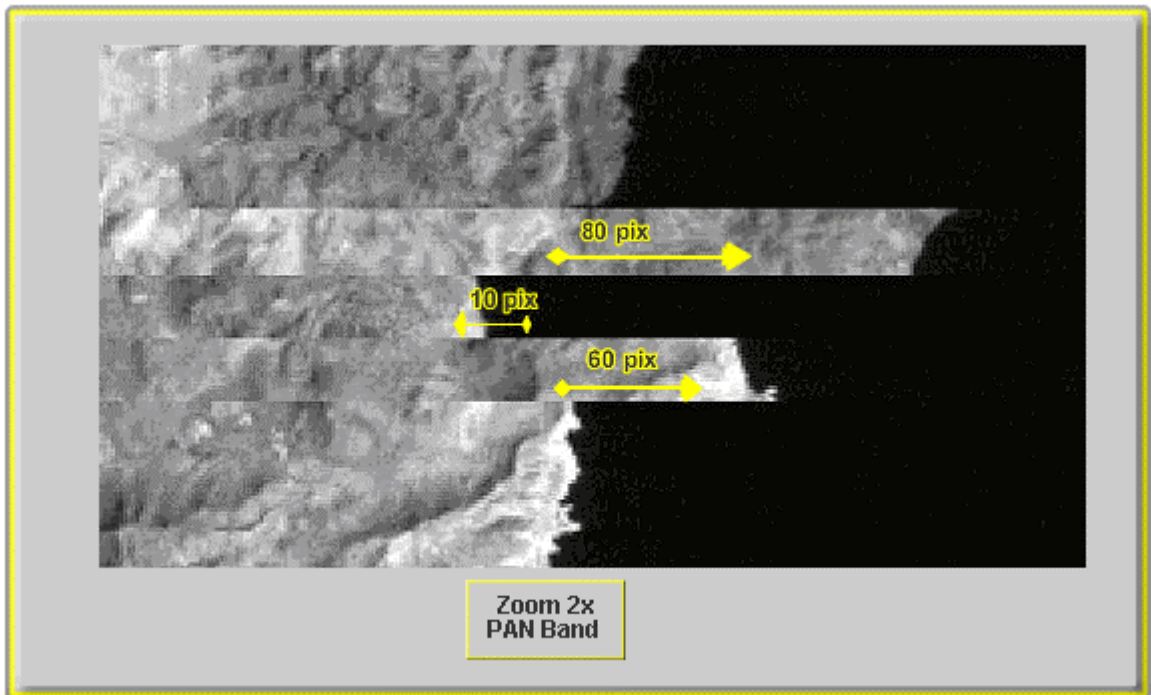


fig. 2 - Several large swath shifts.

Small swath shifts

Usually, small swath shifts (1 or 2 pixels) are easily observed due the difference of contrast close to the image edges; roads, rivers or coasts. The shift value depends on the mirror scan direction. In the figure below, the anomaly occurs mainly on forward scan.

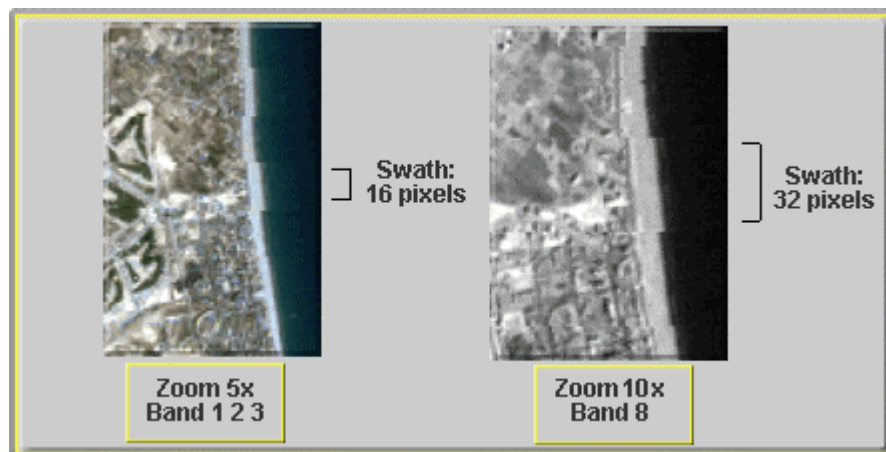


fig. 3 - Small swath shift.

Line displacements

The effect of misaligned lines can be observed as a form of detector patterns magnified by the Nearest Neighbour (NN) resampling.

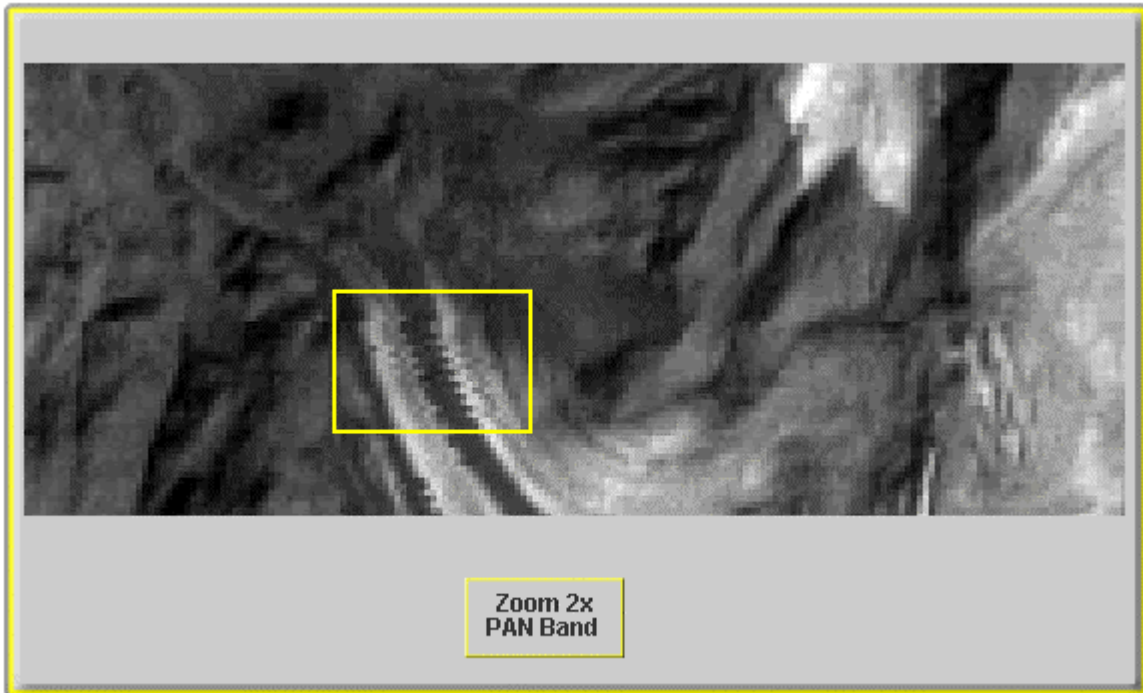


fig. 4 - Line displacements.

Causes

Important swath shifts

Either a time error could occur in the auxiliary information included in the Mirror Scan Correction Data (MSCD). MSCD values are used to compute deviations from the nominal scan mirror profiles provided by the calibration parameter file (scan mirror profile polynomial coefficients). If MSCD information is corrupted the mirror model is not efficient.

Either in case of missing image data, swaths are re-aligned without taking into account the lack of data. Original data are corrupted and any product generated from them will come up with the same anomalies. Additional information about the subject is provided in the next slip (Missing data).

In both cases, this is mainly due to either a bad reception during the downlink period (the loss of minor frames) or degradations of the recorder media (especially with LANDSAT 5 products).

However, in few cases, the on-board computer provides inconsistent MSCD values.

Small swath shifts

This anomaly occurs during the processing phase. Small shifts are due to a wrong geometric correction.

Line displacement

An resampling error of the detectors might be performed along the scans. This error in the range from 0.5 to 1 pixels may be magnified by the (Nearest Neighbour) resampling method.

Consequences

The swath and line anomalies arise on any band. For any scientific purposes, the bad geometrical quality implies that the product is unusable. If a time error occurred on auxiliary information caused by a single bit error, there is no mean to recover the data. Other bit errors may also affect the pixel values and could produce radiometric anomalies.

Disposition concerning the swath shifts

Large swath shifts

Gael Consultant proposes the “**scrap**” disposition and the product has to be segregated.

Small swath shifts

Gael Consultant proposes the “**scrap**” disposition or the “**use as is**” disposition (automatic waiver) depending on the amplitude of the observed displacements. According to these dispositions, the product has to be respectively segregated or sent to the user.

Line displacement

Gael Consultant proposes the “**scrap**” disposition and the product has to be segregated.

Preventive and corrective actions

Preventive actions

Gael Consultant proposes the following preventive action:

- User must be aware that ordering products with the “Nearest Neighbour” resampling option may lead to small swath shifts.
- Station operator must remind that when a product has been generated with the “Nearest Neighbour” resampling, small swath shifts are allowed up to one (1) pixel. Over this value the part of the product being checked shall be considered as corrupted.

Corrective actions

Gael Consultant proposes the following set of corrective actions:

- If an error occurs on MSCD data, there is no correcting strategy that can rebuild these values from the adjacent swaths. ESA and EURIMAGE have to determine how to handle data with important shifted swaths.
- The processing chain manufacturer has already corrected the software concerning the small shifts of swath and also the line displacements. In fact, these anomalies were corrected on January 2001.

Some advice to go further

Test drawbacks

In “*supervision mode*”, the station operator must visually check if the detected defect is real (“true”) or not (“artifact”).

The main drawback of the “Swath and lines alignment” test is to make confusion during the correlation between the displacements of swaths and the “natural offset” due to the inclination of sub-horizontal structures (streets, fields limits, beach...).

Duplicated lines – shifted swath

Duplicating lines is required to geometrically correct the scene for the three following reasons:

- The orbit tilt against the Earth rotation,
- the scanning period against the spatial resolution,
- the product projection.

An unusual count of duplicated lines can be detected using the “Duplicated Lines” test. This latter one calculates the frequency of the detector identifiers in the product.

When a line is duplicated, specifically when the “Nearest Neighbour” resampling is used, slightly edge discontinuity can be interpreted as a shifted swath or line. The figure below illustrates such a case.

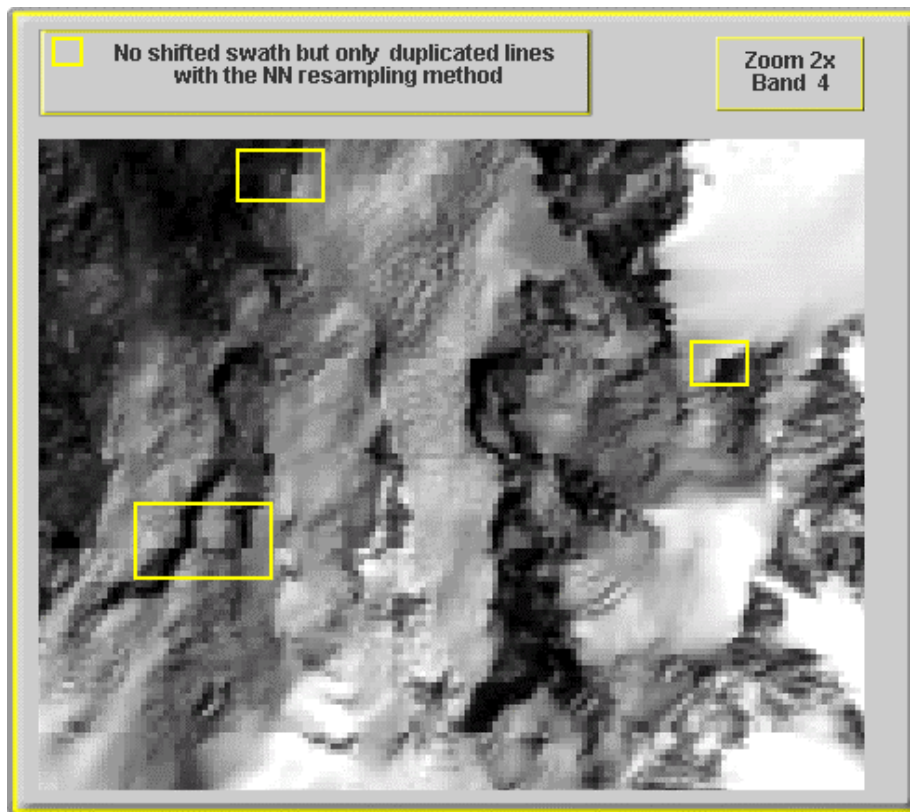


fig. 5 - Duplicated lines and resampling method.

Nearest Neighbour resampling method – shifted lines

The “Nearest Neighbour” (NN) resampling introduces a small spatial error into the output image. During a geometrical processing, the image may be offset along the horizontal by up to a half (0.5) pixel, causing a “blocky” appearance. As a result, the rounding process induced by the NN may lead to shifts of 1 pixel.

In addition, the geometrical displacements are not exactly the same on all bands. This is due to the fact that each detector are placed differently on the detector arrays (please refer to the figure below, *detector*

projection of scan pattern) These displacements may lead to a misregistration between bands for a same pixel. Such misregistration may create colored artefact pixels when composing the bands.

However, the main advantage of the NN resampling method is that the grey level values are not altered, so after the registration, the image can be classified or resampled.

The figure below shows a comparison between the “Nearest Neighbour” (NN) and “Cubic Convolution” (CC) resampling effects on the geometric quality of the VNIR/SWIR Bands.

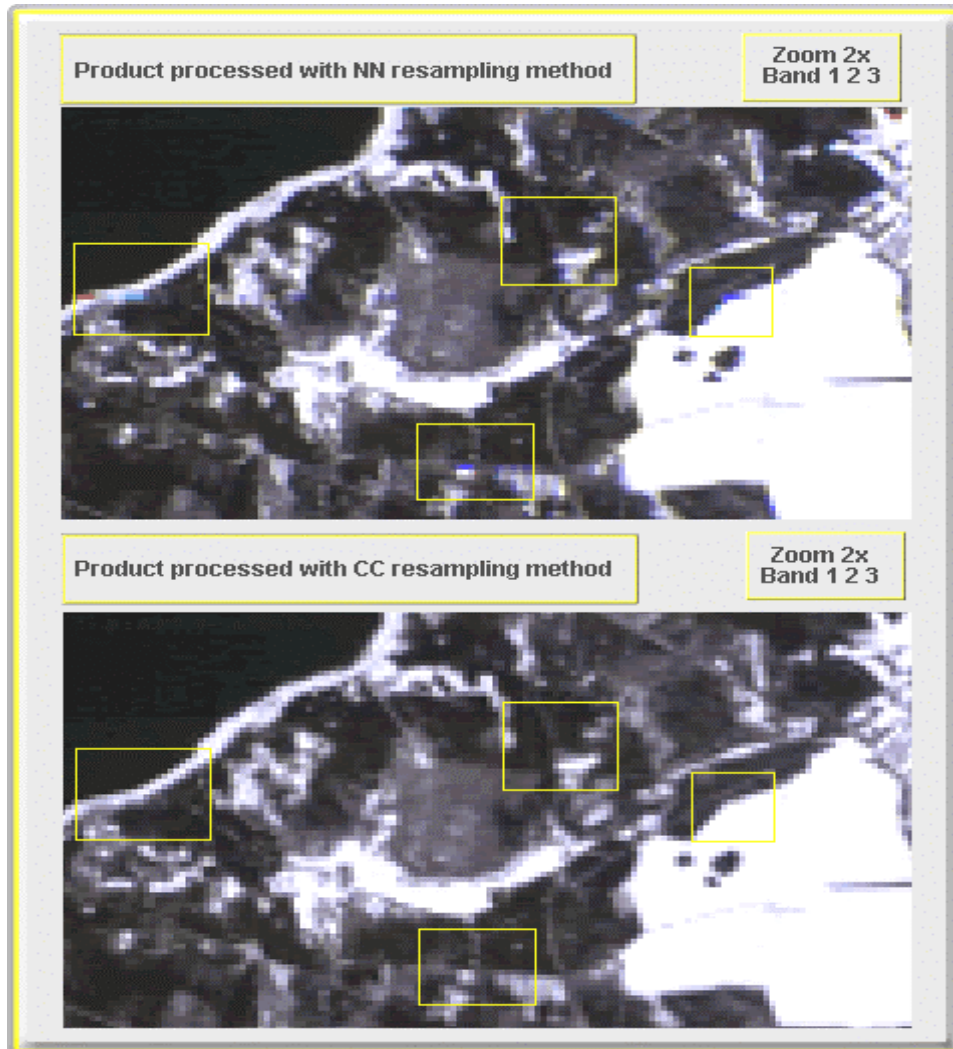


fig. 6 - Resampling method comparison.

With the CC resampling, the image does not have the disjointed appearance produced by the nearest neighbour resampling. As the grey level values are altered by this method, any image classification processes should be performed before the resampling.

The ETM+ scan pattern

The figure below illustrated the line displacement anomaly because the one pixel shift between successive lines can be associated to the detectors offset.⁴

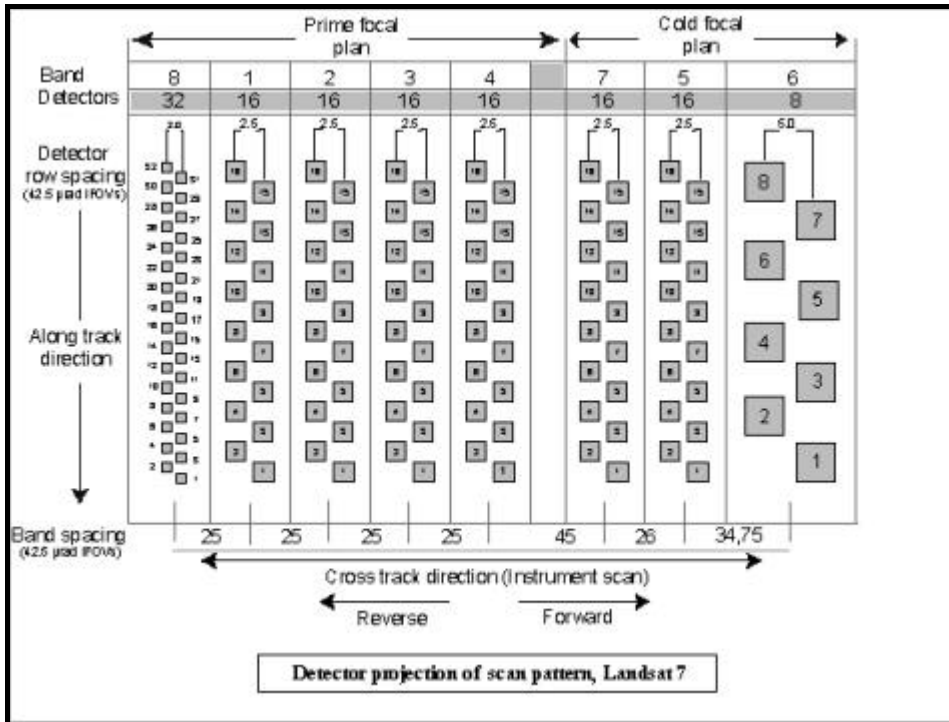


fig. 7 - Ground projection of ETM+ scan pattern.