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JERS-1 : VALIDATION OF OPTICAL SENSOR PRODUCTS

JERS-1/OPS VNIR, band 3,2,1 colour composite
Pyrenees Atlantiques, acquired 17/01/93

JERS-1: VALIDATION OF OPTICAL SENSOR IMAGES

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Summary: The scope of this document is to assess, and validate the JERS-1 Optical Sensor (OPS) data processed by ESA.

The format, the geometry, and the radiometry of the OPS data have been checked.
In order to improve the quality of the OPS Visible and Near Infra Red data, some corrections have been tested.

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1 Introduction

The purpose of this document is to check, and to validate the JERS-1/OPS products as it is described in the ESA document No BO-921223-01, JERS-1 Optical System Format Description (referred hereafter as ref. 1)

Launched in 1992, by the NASDA, JERS-1/OPS is a high resolution satellite which carries an all weather Synthetic Aperture Radar (SAR), and an Optical Sensor (OPS). OPS gives optical data in the visible and near infra-red (VNIR), and short wave infra-red (SWIR) wavelength, and provides stereoscopic images taken in the same track.
ESA acquires OPS data in the Fucino Station, and in the Kiruna Station. Two kinds of products are processed delivered: raw data, and system corrected (S/C) data for which geometrical corrections and radiometric corrections are applied.

The validation has been carried out using a set of ten images; the format, the geometry, and the radiometry have been checked.
The validation has been done for VNIR raw, VNIR S/C, and SWIR raw. No SWIR S/C will be implemented since the instrument has been turned off.

2 DATA AVAILABLE AND TOOLS

2.1 Data available

Ten images have been studied for this validation:

-Image 1

geographic area: centre Spain, North east of Madrid, Path number 328, row number 232
date:19-01-1993
acquisition station:Fucino
data: VNIR S/C, SWIR raw
characteristics: image clear without clouds, important relief with valley and crest, lake.
recorded on CCT

-Image 2

geographic area: Netherlands, Path number 319, row number 213
date: 23-02-93
acquisition station: Fucino
data: VNIR S/C in, SWIR raw
characteristics: image clear without clouds, plain with cultivated fields, river, tracks of snow
recorded on exabyte

-Image 3

geographic area: south Italy, Path number 289, row number 233
date: 22-04-93
acquisition station: Fucino
data: VNIR raw
characteristics: image with land and sea, clear with some little clouds
recorded on exabyte

-Image 4

geographic area: french Alpes, Path number 313, row number 226
date: 17/02/93
acquisition station: Fucino
data: VNIR raw
characteristics: important relief, one lake, some snow, quite clear.
recorded on exabyte

-Image 5

geographic area: south west of France, near Bayonne, Path number 326, row number 228
date: 17/01/93
acquisition station: Fucino
data: VNIR raw

characteristics: sea, plain, mountain, river, some clouds in left down corner of the image
recorded on exabyte

-Image 6

geographic area: Sierra Nevada in South Spain, Path number 326, row 239
date: 17/01/93
acquisition: Fucino
data: VNIR raw
characteristics: sea, mountain, cloudy in the north west
recorded on exabyte

-Image 7

geographic area: Isle of Elba, Italy, Path 305, row 229
date: 08/05/93
acquisition: Fucino
data: VNIR raw
characteristics: an Island, sea, a part of italian coast, clear
recorded on exabyte

-Image 8

geographic area: area of Carcassone in South France, Path 319, row227
date: 10/01/93
acquisition: Fucino
data: VNIR raw, SWIR raw
characteristics: mountains, grape fields, city, clear
recorded on exabyte

-Image 9

geographic area: South Italian and french border
date: 09/08/93
acquisition: Fucino
data: VNIR raw, SWIR raw
characteristics: sea, mountain, cities, clouds in north
recorded on exabyte

-Image 10

geographic area: South Italy, Calabria
date: 21/07/93
acquisition: Fucino
data: VNIR raw, SWIR raw
characteristics: sea, coast, hills, clear
recorded on exabyte

2.2 Tools

The software for the acquisition and processing OPS data runs on Silicon Graphics Workstation. Image have been chosen with the help of the quick look display by downloading the HDDT and displaying the quick look; this software has been developed by ACS (Advanced Computer System) and is running on Silicon Graphic in ESRIN.

The size and the data of each files have been checked with TAPE INSPECT, and DUMP.
The images have been studied with ERDAS/IMAGINE version 8.02, and PV-WAVE software running on a Unix Sun workstations. ERDAS/IMAGINE is still a demonstration version, so a lot of bugs and problems have been found. ERDAS/IMAGINE has been well appropriated to display images, to check the size of the images, to assess the quality of the System Corrected products by making a colour composite image, and to evaluate the geographical position in the image.

The geographic coordinates in latitude and longitude in the images have been processed with a fortran program called corner.for with the following input:
the scene centre localisation, the semi major axis, the inclination, the pixel size, and the distance in pixels between the scene centre and the point.

In order to evaluate the geometrical quality of images, a 1 : 25 000 Map from IGN has been used.

PV-WAVE has been very useful to study the radiometric problem affecting the VNIR and the SWIR data; the FFT algorithm uses by PV-WAVE is the Cooley-Tuckey FFT algorithm (ref.2).

3 FORMAT

Each file, Volume directory, Leader, Imagery, and Null Volume Directory, have been checked record by record, and have been compared with the ESA format, as described in the ref. 1. The following problems have been noticed:

3.1 Volume Directory File

(see ref. 1 annexe 4.0 page 1, 2, 3,4, 5). Two differences have been found between the document and the volume directory field read on the tape:

In the image 2, for the acquisition station symbol AA, we read FC instead of FU for Fucino. For others images the abbreviation FU is correct.

Volume directory file, Text Record, Byte 117: in the Volume Directory File, Text_Record, the last record, the scene identification is not completely written. The normal scene identification is MNSYYDDDPPPRRRAA (see ref. 1 for the description); instead of this, it is written MNSYYDDDPPTHFIXD, and the electronic system of the Space Segment Information, at byte 167, is 0 instead of 1 or 2.

3.2 Leader File

(see ref1, annexe 4.0 page 6, 7, 8, 9, 10, 11, 12)

The leader_file has been checked with Dump utility, and following remarks sending by the Swedish Space Corporation, some problems have been found.

Leader File Scene Header Record

.-Byte 357: orbit direction is ASCENDING. According to ephemeris, it should be DESCENDING.

-Byte 1541: Resampling Algorithm Designator.
In the leader file we read NO RESAMPLING for raw data instead of NONE; for system corrected, we can read in the file SYSTEM-CORRECTEDCUBICCONVOLUTION instead of CUBICCONVOLUTION as it is written in doc 1 p.9

-Byte 1653: Bands Available.
Format is A8 instead of A64 as in the description.

-Due to the error at the Byte 1653, Interleaving Indicator starts at byte 1661, and not at byte 1717 as in the description.

Leader File Ephemeris Record

-Byte 21: GMT Ground Time
Format is <YYMMDD HHmmSSttt> instead of <YYMMDDHHHmmSSttt> as in ref. 1.

-Byte 47 Time Error.
The format is A10 instead of A8 as in ref. 1.

-Byte 55: The First Ephemeris Segment.
It starts at Byte 57.

-Byte 55 (Actually Byte 57, but 55 in ref. 1) Time (GMT) of orbit data.
Same format difference as at byte 21.

Leader File Telemetry Record

-Byte 13: Telemetry Sequence Number
Format is A2, not A4 as in ref. 1.

3.3 Imagery File

-Imagery File, File Descriptor Record has been checked with dump: the file is correctly written

-Imagery_File (see doc 1, annexe 4.0, page 13,14,15): the size of images has been checked. The size of raw images is 4096 x 3200 pixels; the size of system corrected images is 4096 x 4096. The right border pixels number, the left border pixels number are correct. The imagery file is organized as it is shown in ref. 1 page 17 and 18.

3.4 Null Volume Directory File

-the last file on the tape is the Null_Volume_Directory_File (see doc 1, annexe 4.0 page 16): The Null_Volume_Directory_File is correctly written.

3.5 Remarks

A remark about the format has been sent by Pr. Dowman from University College of London. "There is information not available in the header. We need to know the timing for oblique view. The header only contains the timing for the vertical view."
The information about the timing for oblique view could be read in the imagery file, Image Record, for each line from byte 17 to 20. But it would be useful to have some specific informations for band 4, as scene centre, time of scene acquisition...The informations given in the Volume Directory File, and in the Leader File concern only the vertical view (band 1,2,3)

In the Leader File, Ephemeris Record: the format could provide the number of ephemeris given. Ref.1 should indicate that this number is equal or less to 26.

Leader File, Telemetry Record: Byte 17., Sequence of Telemetry minor frames(32 minor frames of 128 bytes each). Swedish Space Corporation sent this remark: "byte-17 Sequence of telemetry minor frames. Some minor frames are completely missing. In some minor frames parts of the data are zeroed.".
32 is the maximum number of minor frames. The missing bytes are put to zero. Ref.1 should indicate it.

At this time, the system corrected product delivered by ESA provides only the band 1, 2 and 3 of VNIR. It could be interested to add the band 4, and to create a system corrected also for SWIR, in spite of the quality of the data.
A remark sent by Mr. Tuomisto from NBS Finland confirm this proposition: "We feel that it is important to our organisation that ESA creates the possibility to process system corrected data. We have no ready programs which could be used to make the system corrections in our organisation nor have the necessary resources to develop the system correction programs. So we'd like to get the images as system corrected."

Due to the instrument conception, the SWIR data are not registered to each other. Between each band, there is a difference of some lines. So without a processing, and control points in the images, the 4 bands in the SWIR can't be superimposed. It could be more useful to deliver exactly the same area for SWIR and VNIR data.

4 GEOMETRY

4.1 Images

Each spectral band in each radiometer has a 4096 elements linear charge coupled device (CCD).

Raw VNIR and SWIR and VNIR System corrected images have been studied. Raw images have a pixel size of 18.3 x 24.2 m, system corrected have pixel size of 18 x 18 m. The resampling processing used is the cubic convolution.

Some special forms like straight road, airport, lakes, river or coast have been looked at with more attention. A comparison with geographic map have been also carried out. With regard to the map, the images don't present any deformation; the geometrical forms are regular, there is no break in the straight forms.

Distances between two ground control points, such as lakes, or bridges haves been measured both in the 1:25 000 map and in the images. For example, here is the result found for two ground control points for raw image 4.

Lake: image d=11680 meters
map d=11775 meters

Bridge: image d=800 meters
map d=875 meters

For raw images, the results are quite good.

A colour composite with 3 bands in VNIR system corrected, and raw have been made. The bands have been perfectly superimposed. No shift between different bands has been noticed.

4.2 Geographical Position

The precision of the geographical position given by OPS has been checked.

Two images have been used:

-image 4 in the french Alpes for which we have 1:25 000 maps from IGN France.

-image 7 in the Elba isle, for which one it was easy to take some ground control points.

The latitude, and longitude position in the image have been calculated from:
-the semi major axis
-the inclination of JERS-1

-the difference in kilometres between the pixel and the centre pixel: we took as pixel size, 18.3 x 24.2 m.

-the latitude and longitude of the scene centre read in the leader file.

For the image 4, five ground control points (GCP) have been selected, mainly lakes, dam.

The following results in the table I give the localisation, latitude and longitude, in degree for, the image, the map, the difference, and an approximate conversion of the difference in kms:

Table 1:

GCP	image	Map	difference	difference in kms
1	44.5874 6.2935	44.4749 6.2709	0.1125 0.0226	12.454 1.7967
2	44.6661 6.3628	44.5348 6.3694	0.1313 0.0066	14.5349 0.5247
3	44.6973 6.3075	44.5529 6.2905	0.1444 0.0170	15.9851 1.3510
4	44.6680 6.1092	44.523 6.071	0.1446 0.038	15.9917 3.021
5	44.5254 6.1185	44.4562 6.2008	0.0692 0.0823	7.6604 6.5428

The difference found is big, specially the difference in latitude.

The latitude and longitude data of the scene centre given in the leader file is wrong. For the image 4, the difference between the scene centre read in the leader file, and the scene centre position read on the 1:25 000 map is at least 5 kms in latitude.

At this time, ACS is investigating the problem and shall provide both an explanation and an improvement..

For the image of Elba, 9 GCP have been selected, crossroads, inlet, small isle...etc. It was easy to identify these points both in the map and in the image. A big difference between the image and the map have been noticed. The average difference in latitude is more than 15 kms; in longitude the difference is less important, but is still big, around 6 kms.

5 RADIOMETRY

5.1 Problems

At this time no radiometric conversion is applied.

The dynamic range is very narrow. The data are written on 6 bits. The pixels values are lower than 64. The histogram, specially in the band 1, is narrow. For example, in standard gain, it could be difficult to make a spectral classification.

For the OPS acquisitions two gains can be chosen: high gain and low gain. By default acquisition is done with high gain. Over bright target low gain shall be taken.With a high gain, clear area like desert, dry land are saturated in near infra red or infra red. The data on the desert, or dry land must be acquired with a lower gain. The gain can't be changed within the same path.

Moreover, NASDA announced three different problems (ref. 3 and ref. 4):

-a vertical striping due to each detector's unbalanced sensitivity; this striping is supposed to be corrected by the radiometric algorithm conversion given by the NASDA (ref. 4).

-a vertical striping in SWIR due to abnormalities in components of the power supply. There is a delayed response, which depends on the CCD's number, odd or even.This striping is not regular and takes place in the area where the contrast is important, like land-sea, land-lake, snow-land; It is very strong specially in the channel 5. For these reasons the correction is difficult and not yet found.

-a horizontal striping with a frequency around 100 Hz in VNIR caused by "oscillations arising from abnormalities in the VNIR power supply components." (ref. 5)

NASDA has decided to not apply a correction algorithm for this striping.

The striping frequency is around 100 hz. It means 10 lines each 29 lines are not correct. In the image, it produces one bad line each 3 lines, and sometime, every 30 pixels 2 bad lines.A constant offset within the same line produces this striping.
Moreover this striping is not regular and its intensity is depending on the images and is different within the image. The image 5 is quite clear while the images 3 and 7 are really bad. The band 4 is better than the others. More details can be found in Bizzi et al., 1994.

5.2 SWIR problems

A very strong vertical striping in SWIR has been noticed. There is a delayed response, which depends on the CCD's number, odd or even.This striping is not regular and takes place in the area where the contrast is important, like land-sea, land-lake, snow-land (see fig 1.). As far analysed this striping is strong specially in the band 5.
Too much information is lost, and for this reason the correction is very difficult. At this time, no good correction has been found.

As far analysed, here is a description of the problem in band 5:

"regular vertical striping": for homogeneous area, such as the sea in image 9, a shift of 2 or 3 numeric counts (data on 6 bits) between odd and even columns can be noticed.
The figure 1 shows a line on the sea extracted from image 9 band 5.

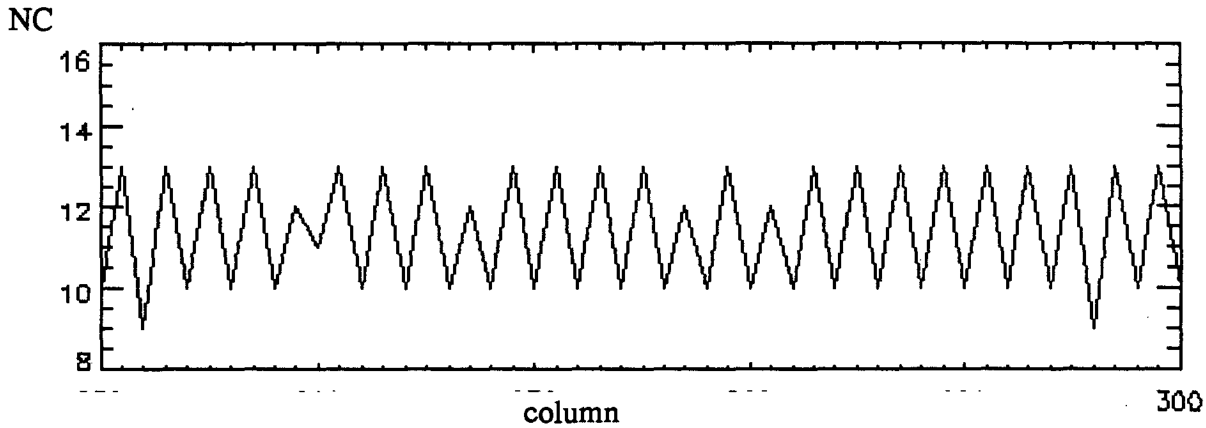


FIGURE 1. difference between odd and even column in sea area.

The difference between odd and even columns is obvious. The mean of the difference is 3 numeric counts.
This striping is regular, and can be easily corrected by a Fast Fourier Transform filter, or by adding or subtracting an offset for odd and even columns.

"non regular striping": there is also a non regular vertical striping, which depends mainly on contrast in the vertical direction. It is produced by a delayed response of each CCD.
The value of one pixel depends also on the value of the previous pixels. This problem takes place in whole image, but it is more important for odd columns.
This phenomena produces a blurred image.

It is obvious particularly in area where contrast is strong, such as land / water.

The problem is shown in figure 2. After the coast, there is an overflowing of about 20 pixels for even columns, then 35 pixels for odd columns.

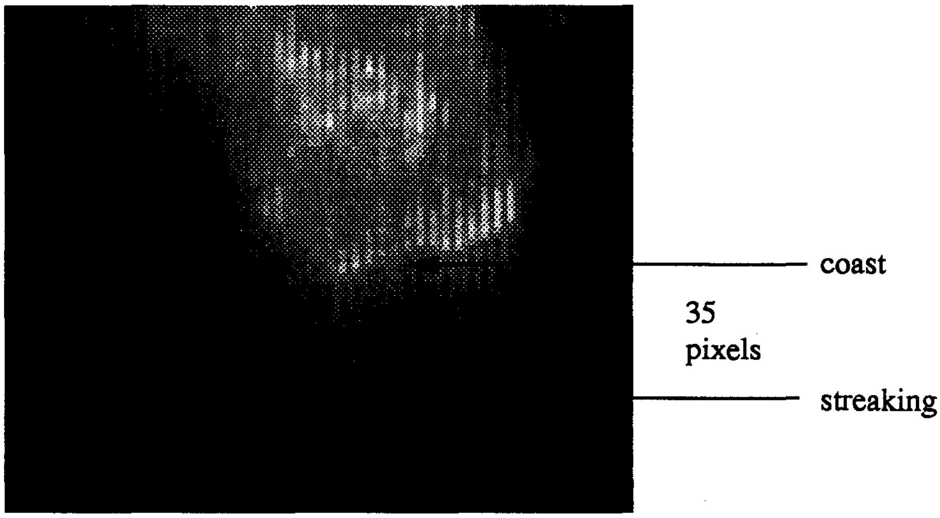


FIGURE 2. SWIR band 5, zoomx4

The figure 3. shows two columns (odd and even) extracted from this image. It is a transition between land and sea.

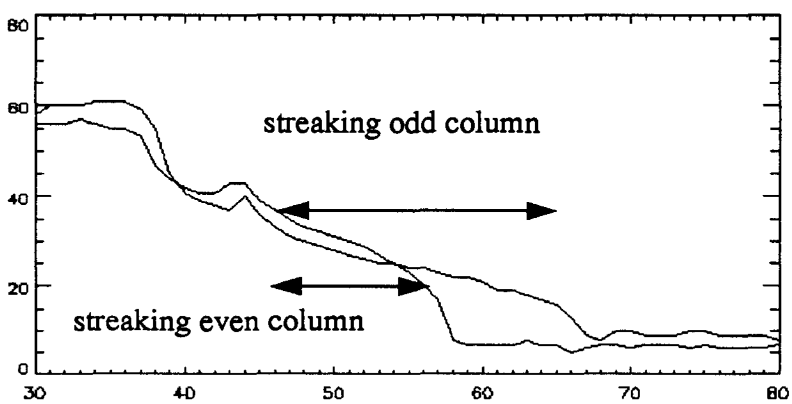


FIGURE 3. odd and even columns, band 5

The transition between land and sea is progressive.

The figure 6. presents exactly the same column on the same area extracted from Landsat5 TM, band 5 which has a similar spectral response.(1550-1740 nm).

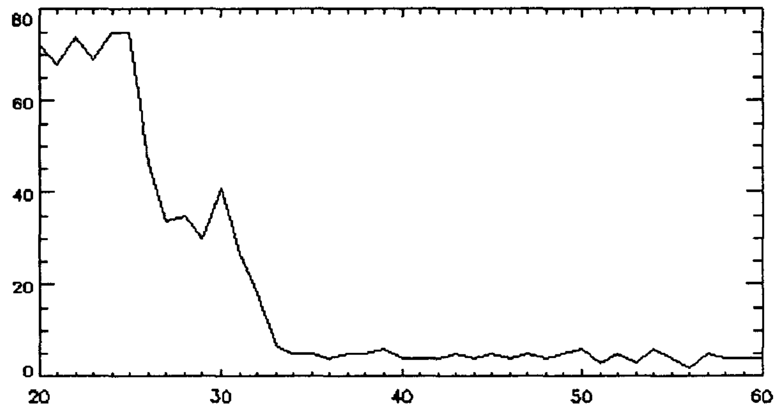


FIGURE 4. column extracted from Landsat 5 TM, band 5.

The difference is obvious. This time, the transition between land and sea is clear, and fast.

The problem is quite complex, because whole image is affected in an irregular way. The amount of information lost is too much important to correct it.

At this time, no good correction has been found yet.

The problems take place mainly in the band 5, and in the band 6. The bands 7, and 8 are better

5.3 VNIR problems

All the VNIR bands are affected by both a horizontal, and vertical striping.

-The vertical striping is very regular. There is an offset between odd and even columns. It can be easily corrected (Bizzi et al., 1994).
The value of the offset is calculated by the difference between the average value of the odd columns and even columns.
The processing time is fast, and the correction is good.

-The horizontal striping is the more important.
Some lines (about 1 line / 3) present a radiometric level lower or higher than the adjacent lines. The frequency of the phenomena is around 100 Hz, which means 1 line per 2.89: in the image, this non integer frequency gives an irregular spatial distribution.

The radiometric difference between noisy lines and good ones is not constant in the whole image.

This difference is constant within a single line.

The noisy lines can be detected by comparison between the average value of one line and the average value of the upper and downer line.

The test is:

if mean(lin(i)) < mean(lin(i-1)) and < mean(lin(i+1))

or if mean(lin(i))> mean(lin(i-1)) and> mean(lin(i+1))

then lin(i) is a noisy line.

The horizontal striping can be described as the repetition of the following sequence:

B-N-N-B-N-N-B-N-N-B-W-N-N-W-N-N-W-N-N-W-B.....repetition......

Where B is a black line, N is a normal line, W is a white line.

The offset intensity is not constant and follows a sinus variation.

This sequence has a period of 20 or 23 lines.

The sequence above is just an example; the sequence can be different following the images. But, the period of 20 or 23 is quite regular, and can be found in every VNIR data.

The figure 5. shows an image VNIR band 1, in sea area, zoomed by 12: the above sequence can be seen. The offset intensity variation can been seen on the right side of the image.

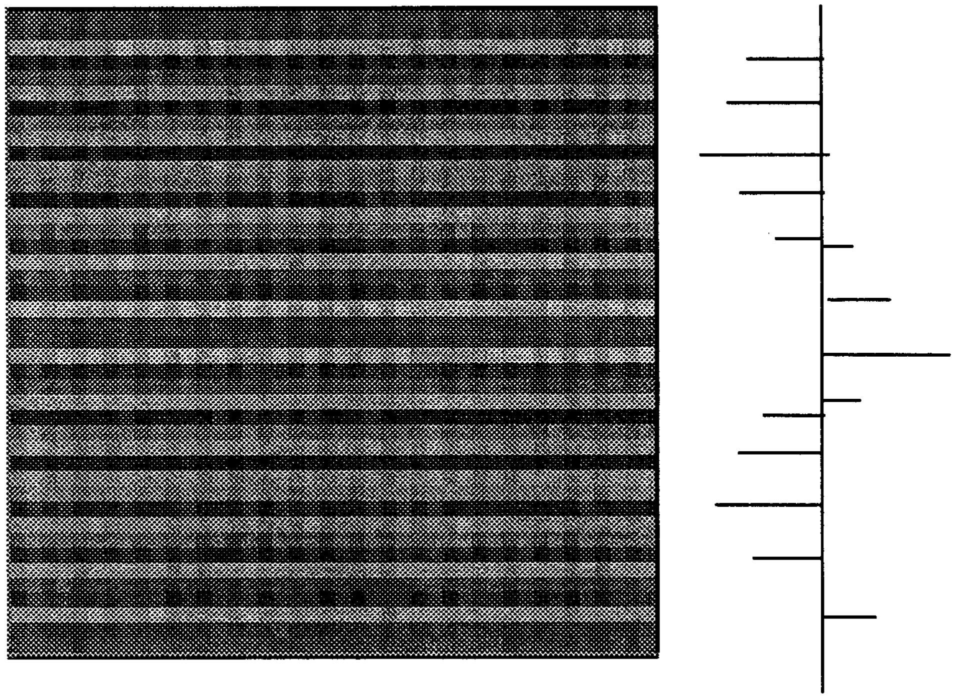


FIGURE 5. VNIR band 1, zoom x 12, horizontal striping

The striping intensity is different in the four bands. It is more important in the first and second band than in the third and fourth ones.

5.4 Fast Fourier Transform analysis

Fast Fourier Transform correction (FFT) has been used with the software PV-WAVE.(ref.2)

A pure horizontal two-dimension signal with period of T will give in the space of spatial frequency, spots in the vertical axe with period of N/T where N is the image dimension in line.

The diagram 1 shows an horizontal striping and its FFT

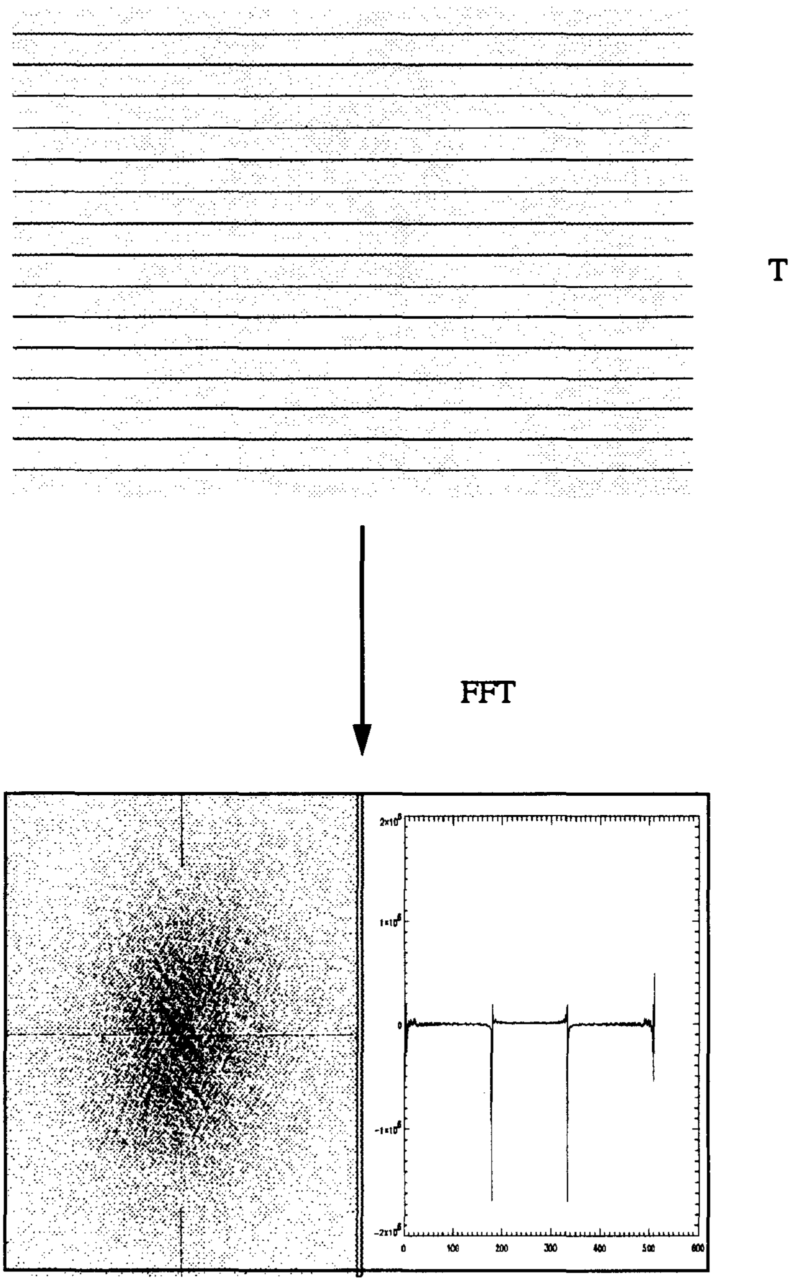


FIGURE 6. an horizontal two-dimension signal, and its FFT

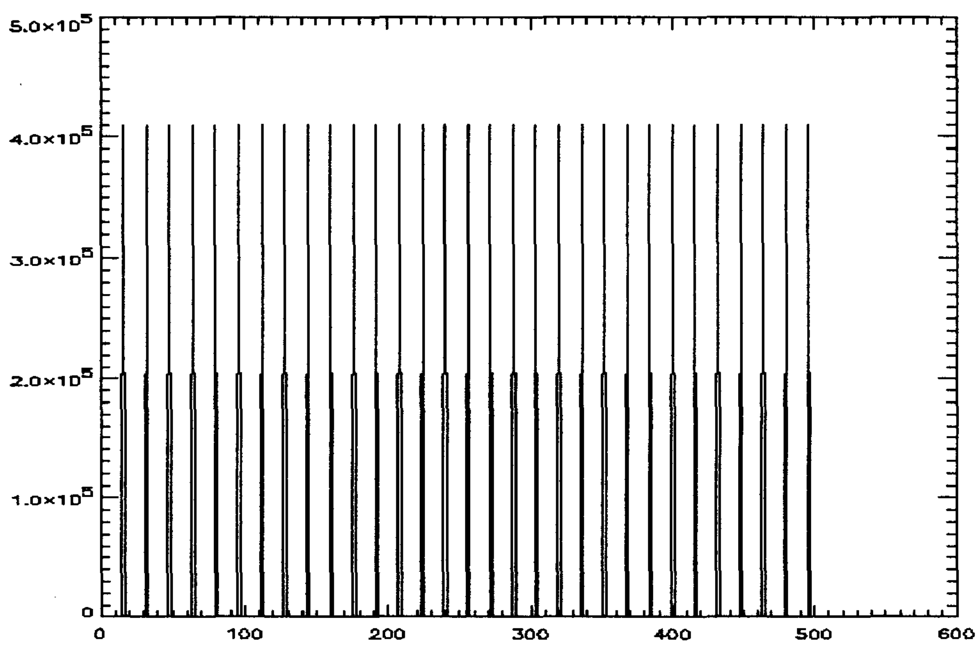


FIGURE 7. vertical axe extracted from the FFT

In the case of a pure horizontal signal, the FFT is a regular signal on the vertical axe with a period equal to N/T.

In the case of JERS-1/OPS, the signal (noisy lines) is horizontal, so its FFT will be on the vertical axe, but the noise frequency is not absolutely pure; the frequency is around 1 line by 3, the intensity of the signal is not regular. So, in the spatial frequencies space, we will have a set of points on the vertical axe, with the main component around N/3.

The figure 8 shows an OPS image 512 x 512 on the sea in the channel 3 (sea is an uniform target where only instrumental noise can produce the signal variation) and a column extracted from the image. Because the sea has a regular spectral response, the striping is obvious.

The figure 9 is the image's FFT, and the vertical axe extracted from the FFT.

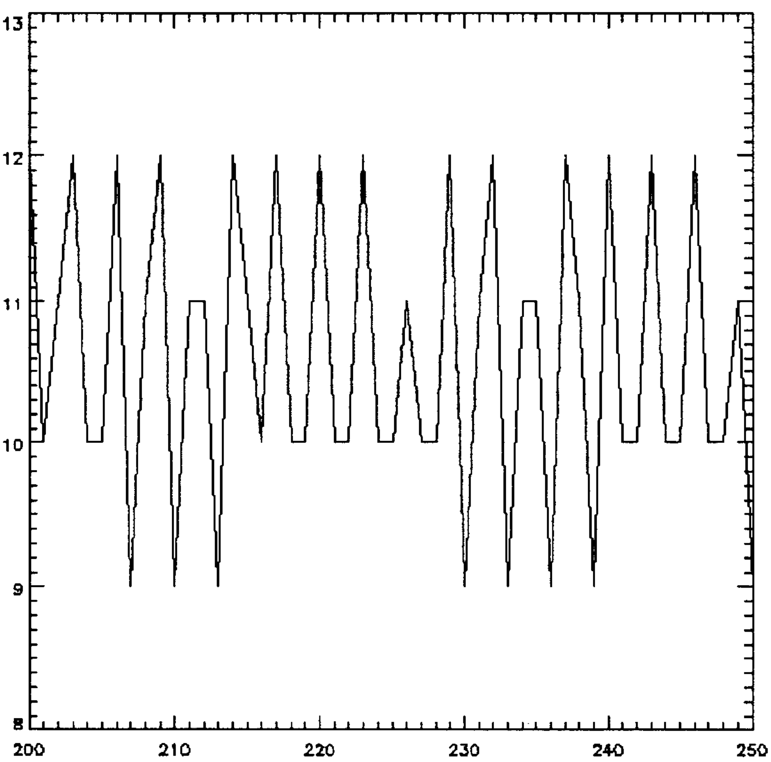
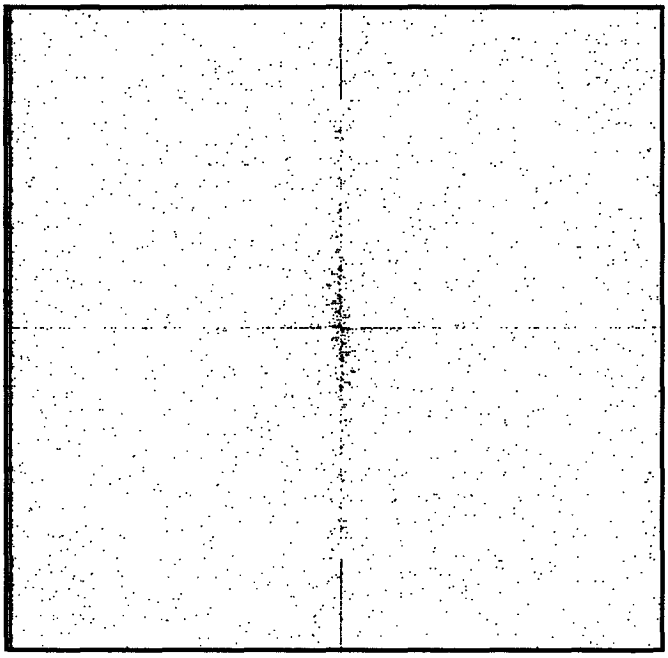


FIGURE 8. OPS image above the sea, and a column extracted from this image



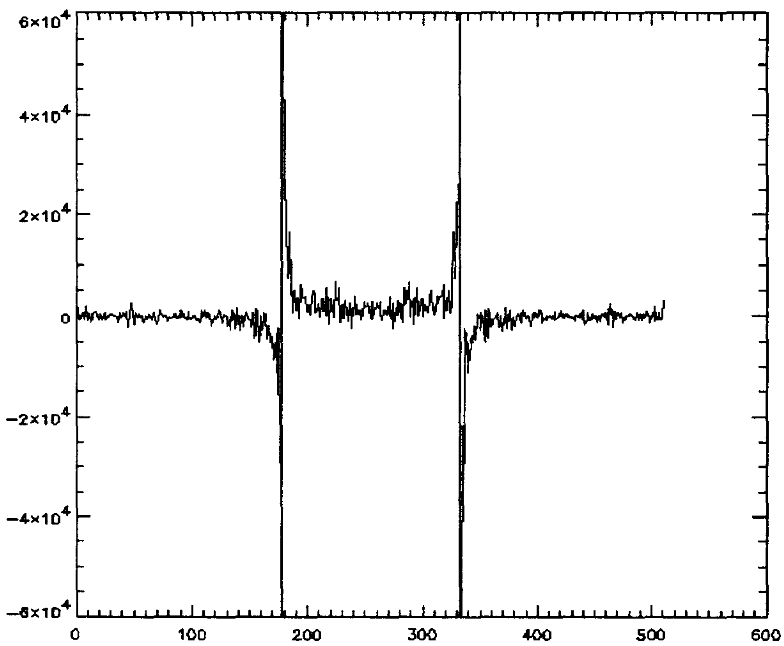


FIGURE 9. OPS Image FFT, and its vertical axe

Two picks, around 170 (512/3) and 340, appear clearly in the vertical axe of the FFT.

The corresponding frequencies produce the striping in the OPS images.

5.5 Testing of correction for the VNIR striping

The following lines describe the correction applied to suppress the horizontal stripping:

(j,k) are the coordinates of one pixel in the image; F(j,k) is the value of the pixel in (j,k);

(u,v) are the spatial frequencies; f(u,v) is the fourier transform of F(j,k)

The steps of the correction are:

F(j,k) —FFT→ f(u,v) —Suppression of noise frequency→ fcor(u,v) —Inverse FFT→ Fcor(j,k)

in our case, the striping is horizontal, so we have to suppress frequencies in vertical axe:

fcor(u,v) = 0 for u=0, and v1< v < v2

= f(u,v) else

For an image NxM

we have:

$$f(u,v) = \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} F(j,k)\, exp\,(-2i\pi\,(ju/N + vk/M))$$

Taking a square image for which the operations are faster, the inverse fast fourier transform is,

$$F(j,k) = \sum_{u=o}^{N-1}\sum_{v=0}^{N-1} f(u,v)\,exp\left(2i\pi\frac{(uj+vk)}{N}\right)$$

where i*i = -1 , and N is the size of the image,

following the definition of Fcor we have

$$Fcor(j,k) = F(j,k) - \sum_{v=v1}^{v2} f(0,v)\,exp\left(2i\pi\frac{(vk)}{N}\right)$$

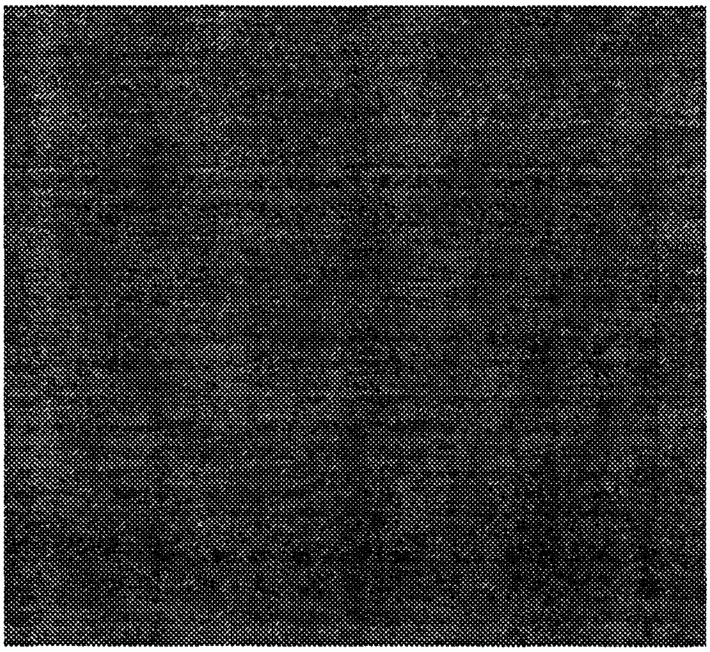
$$\sum_{v=v1}^{v2} f(0,v)\,exp\left(2i\pi\frac{(vk)}{N}\right) = h(k)$$

h(k) depends only on k (of course, also on v1 and v2 which have been chosen), it means that the same value is taken out from each pixel of the same line. This value is stronger for the wrong lines and lower for the good ones, so the good lines are not modified.

A compromise to choose v1 and v2 must be made: it must be big enough to suppress the noise frequencies (the two picks showed in fig. 4), and small enough to not modify whole image. Different values of v1 and v2 have been tried. The picks size is about 20 pixels.
For our applications the best value for v2-v1 has been found equal to 20.

The figure 10 gives the image after the FFT correction, and a part of a vertical line extracted from this image. The striping is not completely eliminated, but it is less strong.

Regarding the figure 3., the corrected signal is now better.



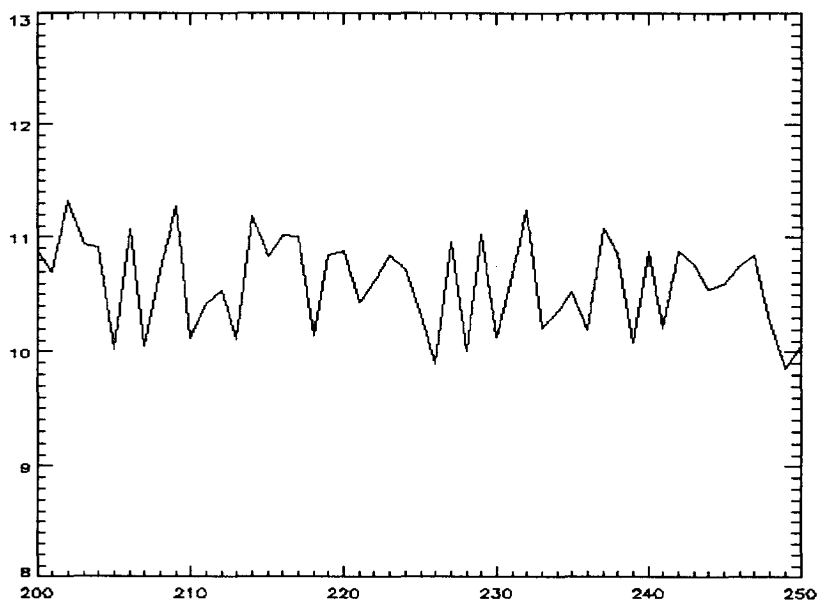


FIGURE 10. OPS image above the sea after FFT correction, and a column extracted from this image

5.6 Limit of the FFT correction

Using PV-WAVE, FFT software running on SUN station, the time processing for an image 512x512 is short, less than 5 sec, with an image 1024x1024 it is less than 10 sec, but it increases very fast with the dimension of image: for an image 3200x3200, it is 43 minutes; the FFT algorithm is faster with an image size that is power of 2, so with whole image 4096x3200 it is very slow, more than 2 h.

Moreover, the distribution, and the intensity of the striping is not regular. So, It is not obvious to suppress only the noise frequency.
Usually, the most important part of images information belongs to the low frequencies range, so if high frequencies are taken out it doesn't affect the image. But, for some particular cases (image with regular fields, or geological phenomena, or a big city image with a regular streets network), some good informations could be suppressed In this case, the FFT correction has to be applied with a lot of carefulness.

The noise frequencies have to be selected either by an automatic test, or by an manual procedure. Anyway, in both case, the choice of these frequencies is delicate, and specific for each image.

The FFT correction is well adapted for a regular signal, which is not the case for a big image 4096x3200. So, the striping does not completely disappear, but it is less strong.

5.7 One Dimension FFT

In order to reduce the time processing, an other method has been tried.

At first, the mean of each line is processed. It is a fast process. By this way the signal due to the striping is extracted. It is now a 1 Dimension signal (dimension is 3200 for raw data). A 1 dimension FFT is applied to this signal; this is also a fast operation. The striping frequency is put to zero, and an inverse FFT is applied. A corrected signal is obtained. The difference between this signal and the raw signal is processed.
In order to suppress the striping, for each line of the raw image, the previous difference found is taken off.

The results obtained is less good than with a 2 dimensions FFT, but it is still correct, and the time processing is fast. It is also easier for automatic suppression of the frequencies because the signal is a 1 dimension signal.

5.8 Comparison line by line

An other correction method has been developed by ACS (Advanced Computer System) and ESRIN (see Bizzi et al., 1994)

The first step consists to detect the noise lines. As indicated in ch. 5.3, the bad lines are detected by the comparison between the average value of one line and adjacent lines.
The default is considered like a constant offset in the radiometric value of each pixel within a line.

The second step is the calculation of the offset, which is the difference between the average value of the line and the average value of the adjacent lines.

The third step is to apply the offset to the current line.

The satured pixels are excluded from the process. The result is given on 8 bits.

This method is more rigorous; the image is studied line by line taking account the locals problems.

Some test have been carried out. The noise frequency is suppressed (it has been checked with the Fourier representation).
Some noise still persist in homogeneous area like sea.

The difference between a corrected image and the raw image shows that only the striping is suppressed. The real information is kept intact.

The processing time is fast, around 3 minutes for 4096 x 3200 image, and it is completely automatic.

The final result is better than the FFT correction.

The following limits of the method are given by ACS:

The specific correction method is applicable exclusively to VNIR raw data with the following exceptions:
-images which contains vast areas of corrupted or missing video data. In this case the histograms will also be corrupted.
-images dimension shall be sufficient to valid the statistic assumptions.
-alteration in the continuity of the lines and/or columns can show uncorrected results.
-it's impossible to apply the correction of the first and last columns of the input image.

6 Conclusion

At first, the format of the data deliver by ESA has been checked. Some small differences have been noticed, but mainly, the data are correctly written.

The geometry has been looked. The images are correct, but a problem concerning the geographic position has been seen. The scene centre position given in the leader file is wrong.We are now investigating this problem. Some solution are still possible.

At last the radiometry has been checked: a final radiometric conversion is not applied yet, but some problems appear, in VNIR and in SWIR.

In SWIR, the problem (a vertical striping) is more important and it is very difficult to applied an efficient correction. At this time, no solution is envisaged.

In VNIR, there is a vertical striping with a frequency (not completely regular) around 100 hz.
The striping is a constant offset within a line with non regular spatial distribution.
A Fast Fourier Transform allows to take off the main part of the striping. This correction is not perfect and takes a long time.
A method developed by ACS and ESRIN gives better and faster results. Each line is compared to the adjacent ones. By this way, the offset is detected and can be suppressed. The result is good, with still some problems in homogeneous area like the sea.

Following remarks sent by some users, ESRIN should deliver a VNIR system corrected product with geometric and radiometric correction including the band 4.
3 products seem sufficient: VNIR raw, SWIR raw, VNIR S/C including band 4 and striping correction.
The calibration coefficient must be available within the format.

In spite of a lot of problems, mainly radiometric problems, JERS-1 can be useful for earth observation, and could maybe replace Landsat in case of gap in TM data (Landsat 6 loss).

Moreover, JERS-1/OPS presents some advantages compared to other satellites. The along track stereoscopic capacity, with band 3 nadir view and band 4 forward view, can provide good results useful for a lot of applications such as geology, cartography, or can produce easily digital elevation model (even without ground control points) which could be used for terrain geocoding (for ERS-1, SPOT for example) (see ref 8, JERS-1/OPS stereo capability).

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ref. 2.
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ref. 3.
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ref. 4.
The Parameters for JERS-1 image rectification and its OPS radiometric conversion algorithm, Document NASDA No HE-92104, May 1993

ref. 5.
JAROS News No 3, 1993

ref. 6.
An Introduction to image Processing, Andre Marion, Chapman and Hall Edition

ref. 7.
Bizzi S, Arino O, Goryl Ph., 1994: Characterization and correction of the vertical and horizontal striping of the JERS-1 OPS VNIR images, proposed to International Journal of Remote Sensing.

ref. 8.
Goryl Ph.,1994: JERS-1 / OPS stereoscopic capability, Document ESA

Annexe 1.Example of Tape inspect, Volume directory file, leader file

Only a little part of the leader file is presented (the file is too long)

-Tape Inspect

file 1: records 1 to 6: size 360

file 1: eof after 6 records: 2160 bytes

file 2: records 1 to 7: size 4320

file 2: eof after 7 records: 30240 bytes

file 3: records 1 to 3201: size 4540

file 3: eof after 3201 records: 14532540 bytes

file 4: records 1 to 3201: size 4540

file 4: eof after 3201 records: 14532540 bytes

file 5: records 1 to 3201: size 4540

file 5: eof after 3201 records: 14532540 bytes

file 6: records 1 to 3201: size 4540

file 6: eof after 3201 records: 14532540 bytes

file 7: record 1: size 360

file 7: eof after 1 records: 360 bytes

eot

-Volume directory File

CCB-CCT-0002 F AJERS1-OPS-01J1V9307291622FU0J1V93128305229FUJERS 1 VNIR BSQ 1 1 1 1 1 1 11993072916225000ITALY ESA-EPO FUCINO 5 7 2

ÛÀh 1J1VNIR00LEADBSQ LEADER FILE LEADMIXED BINARY AND ASCII MBAA 7 4320 4320FIXED LENGTHFIXD 1 1 1 7

ÛÀh 2J1VNIR00IMGYBSQ1IMAGERY FILE IMGYBINARY ONLY BINO 3201 4540 4540FIXED LENGTHFIXD 1 1 1 3201

ÛÀh 3J1VNIR00IMGYBSQ2IMAGERY FILE IMGYBINARY ONLY BINO 3201 4540 4540FIXED LENGTHFIXD 1 1 1 3201

ÛÀh 4J1VNIR00IMGYBSQ3IMAGERY FILE IMGYBINARY ONLY BINO 3201 4540 4540FIXED LENGTHFIXD 1 1 1 3201

ÛÀh 5J1VNIR00IMGYBSQ4IMAGERY FILE IMGYBINARY ONLY BINO 3201 4540 4540FIXED LENGTHFIXD 1 1 1 3201

?h PRODUCT: JERS 1 VNIR 305 229 93 128 00

CREATION: ESA EPO FUCINO 93 07 29 16 22 50

J1V9312830THFIXD09305081024026410OFUCINOSWIR&VNIR

-An extract of the Leader File

?Àà BO-921223-0101 AJERS1-OPS-01 1J1VNIR00LEADBSQ FSEQ 1 4FTYP 5 4FLGT 9 4YNNN 1 4320 5 4320 2 37 16A 2 165 16A 2 309 16A 2 325 16A 2 117 32A 2 213 32N 2 1717 16A 2 1653 64N 2 1525 16A

F2à J1V9307291623FU0J1V93128305229FU +42.6181641 +10.1253653 +1599.0000000 +2047.0000000930508102402641 1305229 659 JERS1 VNIR 305ASCENDING 4 4096 3200 6 RAW NO RESAMPLING 111110000BSQ

(F2à19930508930415 1545000000040664698+000214818930508 101259999 1.8501098800000000e+02 1.1092524189999999e+03 6.8491986600000000e+03 6.8595800000000002e+00 3.1401919999999999e+00 -6.9278499999999998e-01930508 101400000 5.9589847799999995e+02 1.2951630660000001e+03 6.7930075230000002e+03 6.8317969999999999e+00 3.0546240000000000e+00 -1.1795899999999999e+00930508 101459999 1.0042433670000000e+03 1.4755463549999999e+03 6.7077480050000004e+03 6.7748549999999996e+00 2.9560110000000002e+00 -1.6613880000000001e+00930508 101600000 1.4083026060000000e+03 1.6496318369999999e+03 6.5937821089999998e+03 6.6889919999999998e+00 2.8447710000000002e+00 -2.1361289999999999e+00930508 101659999 1.8063509250000000e+03 1.8166756280000000e+03 6.4515940860000001e+03 6.5745610000000001e+00 2.7213710000000000e+00 -2.6017920000000001e+00930508 101800000 2.1966881330000001e+03 1.9759635890000000e+03 6.2817884489999997e+03 6.4320430000000002e+00 2.5863339999999999e+00 -3.0563889999999998e+00930508 101900000 2.5776462499999998e+03 2.1268143049999999e+03 6.0850875619999997e+03 6.2620350000000000e+00 2.4402290000000000e+00 -3.4979800000000001e+00930508

102000000 2.9475966410000001e+03 2.2685820290000001e+03 5.8623287799999998e+03
6.0652480000000004e+00 2.2836740000000000e+00 -3.9246759999999998e+00930508
102100000 3.3049569419999998e+03 2.4006594630000000e+03 5.6144609650000002e+03
5.8425120000000001e+00 2.1173329999999999e+00 -4.3346479999999996e+00930508
102159999 3.6481977339999999e+03 2.5224803609999999e+03 5.3425406970000004e+03
5.5947639999999996e+00 1.9419109999999999e+00 -4.7261369999999996e+00930508
102300000 3.9758492160000001e+03 2.6335220359999998e+03 5.0477280680000003e+03
5.3230519999999997e+00 1.7581530000000001e+00 -5.0974529999999998e+00930508
102359999 4.2865076529999997e+03 2.7333076580000002e+03 4.7312818790000001e+03
5.0285299999999999e+00 1.5668430000000000e+00 -5.4469950000000003e+00930508
102500000 4.5788415619999996e+03 2.8214083959999998e+03 4.3945544350000000e+03
4.7124509999999997e+00 1.3687959999999999e+00 -5.7732510000000001e+00930508
102559999 4.8515976339999997e+03 2.8974453979999998e+03 4.0389858119999999e+03
4.3761669999999997e+00 1.1648620000000001e+00 -6.0748080000000000e+00930508
102700000 5.1036062590000001e+03 2.9610915279999999e+03 3.6660977050000001e+03
4.0211170000000003e+00 9.5591499999999996e-01 -6.3503579999999999e+00930508
102800000 5.3337867120000001e+03 3.0120728819999999e+03

Annexe 2.Image OPS, Band 1 VNIR, Menton

Raw image , and line by line corrected image, in VNIR band 1

esa esrin

european space agency
agence spatiale européenne

Memorandum Ref. DPE/OT-OA930315 16 March 1994

to:	J.P. Guignard	H-DPE/O
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	G. Pinna	DEX/EF
	A. Flati	DEX/EF
	G. Trevisiol, B. Versini, S. Bizzi, W. Spaventa	ACS
from:	O. Arino	DPE/OT

We should, unless already done, produce a characterisation report for users - MA

Sandy NO ANNEX to E94/m70

Subject: Validation of Optical sensor products

Please find enclosed the final report from P. Goryl on the validation of the Optical Sensor products.

Best Regard,

Olivier Arino

DEX/E	A	C	I		A	C	I
H / DEX				LS			
H / DPE				H. CIR			
DPE / O				ADMIN			
DPE / I				PERS			
DPE / IU				H ESRIN			
DEX / EF				DA: FIN			
DEX / EM				REF. N° E94.3.097			
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