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reference GAEL-P232-DOC-002

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## New Third Party Missions Quality Assessment

### IRS P6 - SPOT 4 Comparison - First Assessment

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# 1 INTRODUCTION

## 1.1 Purpose of this document

This document is part of the “New Third Party Missions Quality Assessment” project, and has been done in the frame of the ESRIN Contract No 19565/06/I-OL.

The purpose of this document is the study of the IRS P6 vs SPOT 4 data comparison, this version proposes a quick presentation of the two missions and a first quality assessment in APPENDIX A. Further in-depth analysis may be triggered on ESA request.

## 1.2 Applicable documents

- [AD-1] *New Third Party Missions: quality assessment*  
ESRIN Contract N°: 19565/I-OL  
May 3<sup>rd</sup>, 2006  
ESA-ESRIN

## 1.3 Reference documents

- [RD-1] *GeoTIFF Format for IRS Digital Data Products*  
IRS/DP/SAC/SIIPA/SIPG/TN-07 - July 2002  
IRS DP Team - SAC/ ISRO  
[http://www.euromap.de/download/p6geotiff\\_20041027.pdf](http://www.euromap.de/download/p6geotiff_20041027.pdf)
- [RD-2] *QUISS, Multi Mission Quality Control Manual*  
GAEL-P041-QUISS SUM Issue 2 Rev.7- November 1st, 2005  
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## 1.4 Abbreviations and Acronyms

This section controls the definition of all abbreviations and acronyms used within this document. Special attention has been paid to adopt abbreviations, acronyms and their definitions from international standards as ISO, ANSI or ECSS.

<b>ANSI</b>	American National Standards Institute
<b>CNES</b>	Centre National d'Etudes Spatiales
<b>ESA</b>	European Space Agency
<b>GCP</b>	Ground Control Point
<b>GRP</b>	Ground Reference Point
<b>ISRO</b>	Indian Space Research Organisation
<b>PAN</b>	Panchromatic
<b>RMS</b>	Root Mean Square
<b>SNR</b>	Signal to Noise Ratio (see definition below)
<b>SPOT</b>	Satellite Pour l'Observation de la Terre
<b>TBD</b>	To Be Defined

## 1.5 Definitions

This section controls provide definition of main technical terms used in the present document.

CCD Camera	Charge coupled device (CCD) cameras contain light-sensitive silicon chips that detect electrons excited by incoming light. They also contain micro circuitry that transfers a detected signal along a row of discrete picture elements or pixels, scanning the image very rapidly. CCD cameras use two-dimensional CCD arrays with many thousand of pixels
Dynamic range	The dynamic range of a sensor system is determined by the ratio of the maximum observable energy (Qmax) and the minimum of the still useful energy (noise level Qmin) it is defined in decibels (dB) as $10\log(Q_{\max}/Q_{\min})$ . All radiant energy $<Q_{\min}$ vanishes into noise, while the energy above $Q_{\max}$ disappears into saturation of the detector.
Duty Cycle	Fraction of orbital period in which a sensor is actually operational, determined by the overall power limitations of the payload.
Focal plane array	Focal plane arrays (FPA) are detectors which have more than one row of detectors and one line of detectors together.
IFOV	The IFOV is the angular cone of visibility of the sensor and determines the area on the Earth surface.
LEO (Low Earth Orbit)	The term LEO is used un Earth Observation as well as for communication satellite constellations. These are usually circular or near circular at altitudes less than 200 km above Earth's surface. The orbital period in the altitude range of 300-2000 km varies between 90 and 120 minutes. The visibility period of the satellite over the horizon may varies for an observer (ground station) may vary from about 5 up to 20 minutes.
Radiometric resolution	Radiometric resolution refers to the resolving power of a system in wavelength and energy. The limiting factor for radiometric resolution is the signal to noise ratio of the instrument receiver. Considering the effects of varying illumination, the radiometric dynamic range of a sensor is determined by the maximum radiance value that sensor can experience for a given band.  Measurements are converted into a number of discrete digital levels in a process also referred to as 'quantization'.
Spatial or geometric resolution	Spatial resolution refers to the area on the ground that an imaging system can distinguish. It is measured as the size of a pixel on the ground, when the image is displayed at full resolution ( <i>CCRS Tutorial, 2004</i> ).  Spatial resolution is a function of geometry (scale) between sensor and target for the instant of measurement.
Spectral resolution	The spectral resolution of the sensor represents the capability of the sensor to distinguish fine wavelength interval and is described by the number of band their wavelength ranges.  High spectral resolution is achieved by narrow bandwidths, which collectively, are likely to provide a more accurate spectral signature for discrete observation than broad bandwidths.
Temporal resolution	Temporal resolution is closely related to revisit period, which refers to the interval of time needed by a satellite for one entire orbit.  Absolute temporal resolution is the interval time between two successive acquisitions of exactly the same area.
Signal to Noise Ratio	The ratio of the level of information bearing signal power to the level of signal power. The maximum SNR of a device is called the 'dynamic range'. In general, the higher the signal value is and the better the signal quality for recognition and detection.



## 2 MISSIONS PROFILE SUMMARY

### 2.1 IRS P6

**IRS-P6 (RESOURCESAT-1)** is the most advanced remote sensing satellite built by ISRO. The tenth satellite of ISRO in IRS series, **IRS-P6** is intended to not only continue the remote sensing data services provided by **IRS-1C** and **IRS-1D**, both of which have far outlived their designed mission lives, but also vastly enhance the data quality.

**IRS-P6** carries three cameras similar to those of **IRS-1C** and **IRS-1D** but with vastly improved spatial resolutions : a high resolution Linear Imaging Self Scanner (**LISS-4**) operating in three spectral bands in the Visible and Near Infrared Region (**VNIR**) with 5.8 metre spatial resolution and steerable up to  $\pm 26$  deg across track to obtain stereoscopic imagery and achieve five day revisit capability; a medium resolution **LISS-3** operating in three spectral bands in **VNIR** and one in Short Wave Infrared (**SWIR**) band with 23.5 metre spatial resolution; and an Advanced Wide Field Sensor (**AWiFS**) operating in three spectral bands in **VNIR** and one band in **SWIR** with 56 metre spatial resolution.

IRS P 6 orbit characteristics	
Orbit	Circular Polar Sun Synchronous
Orbit height	817 km
Orbit inclination	98.7 deg
Orbit period	101.35 min
Orbits per day	14
Local time Equator crossing	10.30 a.m
Repetivity (LISS-3)	24 days
Revisit (LISS-3)	14 days
Launch date	17/10/2003
Mission life	5 years

table 1 - IRS P6 technical information.



## 2.2 SPOT 4

The SPOT Earth observation system designed by CNES and operated by its subsidiary, Spot Image, has been in operation since February 1986. In March 1998 the SPOT 4 satellite added its new capabilities to the SPOT family thus enabling Spot Image to satisfy the requirements of users who are now familiar with space imagery. To ensure continuity of service, SPOT 4 will have the same geometric imaging characteristics (a swath of 60 km per instrument and oblique viewing capability of 27° on each side of the local vertical). However its performance has been increased by adding a new shortwave infrared spectral band (SWIR), extending its nominal lifetime from 3 to 5 years and improving operational possibilities.

<b>SPOT 4 orbit characteristics</b>	
Orbit	Circular Polar Sun Synchronous
Orbit height	832 km
Orbit inclination	98 deg
Orbit period	101 min
Orbits per day	14 + 5/26
Local time Equator crossing	10.30 a.m
Repetivity	14 days
Revisit HRVIR	26 days
Launch date	24/03/1998
Mission life	5 years

*table 2 - SPOT 4 technical information.*



### 3 SENSORS AND DATA

#### 3.1 Sensors

Assessments performed are focused on data from LISS 3 for IRS P6 and HRVIR for SPOT 4. The following table gives the technical specifications for both instruments and their fields of application.

Items	IRS P6 - LISS 3	SPOT 4 - HRVIR
Swath width	140 km	60 km
Resolution	23.5 m	20 m, 10 m
Spectral coverage	Band B2 (green): 0.52 - 0.59 $\mu\text{m}$ Band B3 (red): 0.62 - 0.68 $\mu\text{m}$ Band B4 (NIR): 0.77 - 0.86 $\mu\text{m}$ Band B5 (SWIR): 1.55 - 1.70 $\mu\text{m}$	Band B1 (green): 0.50 - 0.59 $\mu\text{m}$ Band B2 (red): 0.61 - 0.68 $\mu\text{m}$ Band B3 (NIR): 0.78 - 0.89 $\mu\text{m}$ Band B4 (SWIR): 1.58 - 1.75 $\mu\text{m}$ Band PAN: 0.61 - 0.68 $\mu\text{m}$
Viewing direction	$\pm 26^\circ$	$\pm 27^\circ$
Radiometric resolution, quantisation	7 bit	8 bit
Scanner type	CCD + push-broom	CCD + push-broom
Fields of application	Agriculture Forest and natural vegetation Land planning and infrastructure Solid Earth resources	Agriculture Forest and natural vegetation Land planning and infrastructure Cartography Environment Oceans and Coasts Urban and suburban

table 3 - Sensors technical specifications.

Pixel size is about 23,5 m for IRS LISS 3 and 20 m for SPOT HRVIR at nadir. This pixel size can reach 25 m for LISS 3 and 21 m for HRVIR at the edges of the scene. The spectral bands are quite the same, with a light difference about few micron. The push-broom scanner type gives a good geometrical coherence to the data.



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### 3.2 Input Data

The data involved in this assessment are located in south of France. The table below gives all information about the data used in the assessment.

	IRS P6 – LISS 3	SPOT 4 - HRVIR
<b>ID</b>	050519P6023038L0020S3 060701P6023038L0020S3 060725P6023038L0020S3	00149170046 00149170047 00149170051 00149170052 40492620607041102261I0_1A_NETWORK
<b>Acq. Date</b>	19/05/05 01/07/06 25/07/06	13/07/03 25/07/03 14/07/03 15/07/03 04/07/06
<b>Product Level</b>	1B	1A
<b>Format</b>	GeoTIFF	DIMAP
<b>Pixel size</b>	20 m	20 m

table 4 - Input data

The following SPOT scenes are not used because of the lack of the files in the DIMAP format :

- 00150389073
- 00150390028
- 00150391001



## APPENDIX A FIRST ASSESSMENT REPORT IRS P6 VS SPOT 4

### A.1 Format

The data are delivered in two different formats:

- GeoTIFF for IRS P6 data,
- DIMAP for SPOT 4 data.

The IRS P6 data is the Geo Ortho Kit images including the camera geometry obtained at the time of the image collection. With the Geo Ortho Kit, users can produce their own highly accurate orthorectified products by utilizing commercial off the shelf (COTS) software, digital elevation models, and optional ground control points. Calibration parameters are not available in IRS P6 data.

The DIMAP format is more documented, the specifications format can be found at the following address: <http://www.spotimage.fr/dimap/spec/dimap.htm>.

The GeoTIFF format specification for IRS P6 data products is available at the following address: [http://www.euromap.de/download/p6geotiff\\_20041027.pdf](http://www.euromap.de/download/p6geotiff_20041027.pdf).

IRS P6 data are also delivered in Super Structure Format but our software do not read this format yet. For more information about this format, the documentation is available on the [http://www.euromap.de/docs/doc\\_009.html](http://www.euromap.de/docs/doc_009.html).

### A.2 Import

While importing data from SPOT 4 product, our import software underlined (warning) that some GeoTIFF tags were not found. Some GeoTIFF tags are not available in the data due to the product level. The table below lists the missing tags (only warning).

TIFFTAG_ARTIST	TIFFTAG_XPOSITION
TIFFTAG_DOCUMENTNAME	TIFFTAG_YPOSITION
TIFFTAG_MINSAMPLEVALUE	TIFFTAG_XRESOLUTION
TIFFTAG_MAXSAMPLEVALUE	TIFFTAG_YRESOLUTION
TIFFTAG_RESOLUTIONUNIT	TIFFTAG_GEOPIXELSCALE
TIFFTAG_SOFTWARE	

table 5 - Import warning - Missing GeoTIFF tags

### A.3 Data organization

Standard form of the folder differs according to the product and satellites.

1. Only the GeoTIFF file is included in the folder,
2. A 'rpc.txt' extension file (for IRS P6 GeoOrtho kit data) is added to the folder. Each channel has its "rpc.txt" file. The "rpc.txt" file contains the camera geometry,
3. A ".dim", ".html", "\_ql.jpg", ".xsl" and ".tiff", files are added to the GeoTIFF file (for SPOT 4 data), which makes this folder more compliant with SPOT DIMAP format.



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### A.4 Image quality

The scenes involved in this topic are chosen by taking into account the acquisition date. They are the following :

- For IRS P6 LISS 3 :
  - 060701P6023038L0020S3 => 01/07/06
  - 060725P6023038L0020S3 => 25/07/06
- For SPOT 4 :
  - 00149170047 => 25/07/03
  - 40492620607041102261I0\_1A\_NETWORK => 04/07/06

Note: The nominal LISS 3 resolution is about 23.5 m, the data were resampled to 20 m.

#### A.4.1 Resampling

The IRS P6 data is with the Cubic Convolution resampling mode.

#### A.4.2 Visual Inspection

##### IRS P6 - 060701P6023038L0020S3

The visual inspection shows saturated areas in band 2 (green), specially in water area. Some vertical lines are underlined in band 3 (red) and band 4 (swir). Some examples are presented below.

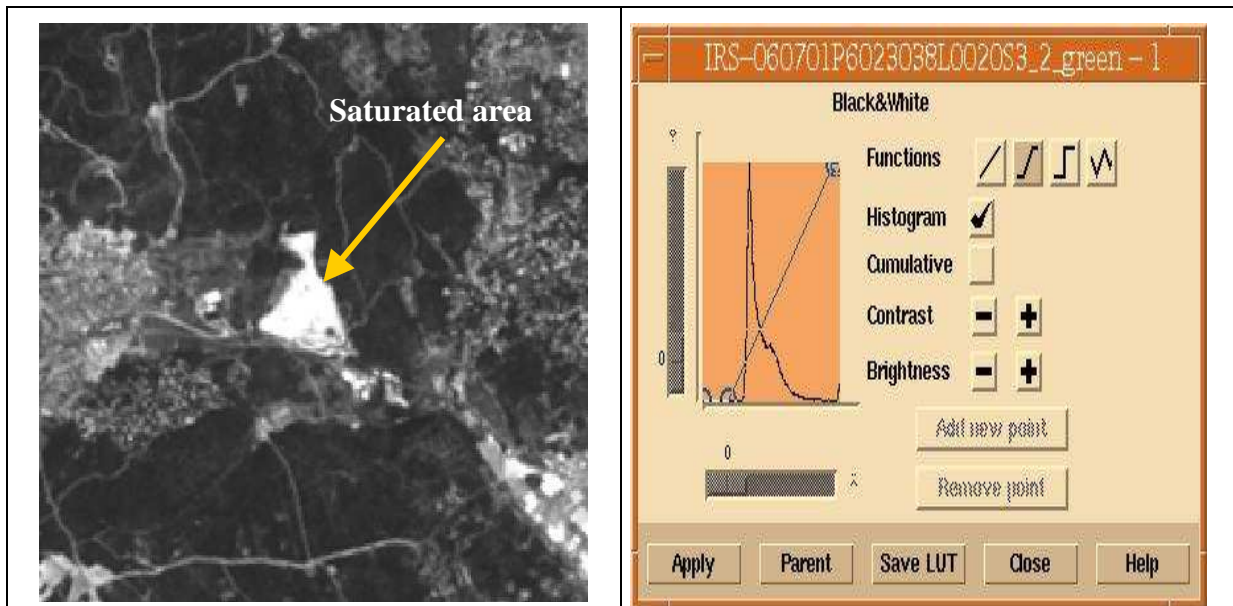


fig. 1 - IRS P6 - 060701P6023038L0020S3 - band 1 (green) - Saturated area



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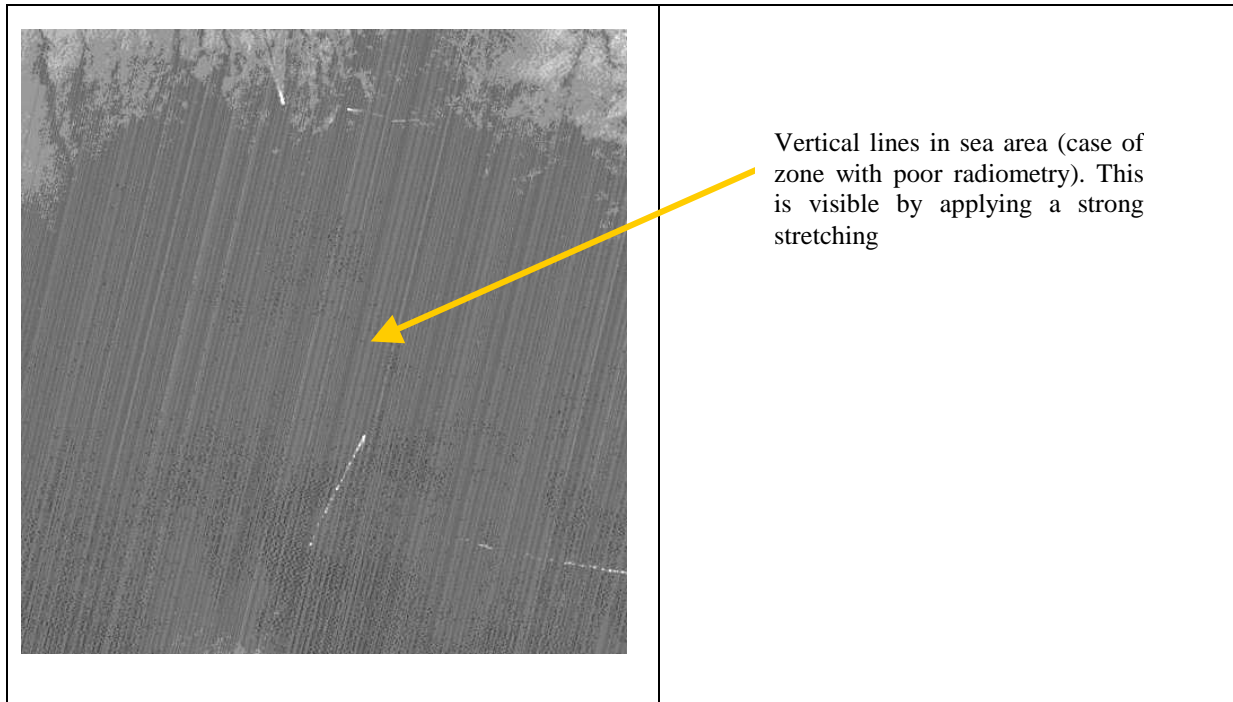


fig. 2 - IRS P6 - 060701P6023038L0020S3 - band 2 (red) - Vertical lines

### SPOT4 - 40492620607041102261I0\_1A

Some vertical lines are observed in band 4 (MIR), maybe due to an inconsistent behavior of CCD.

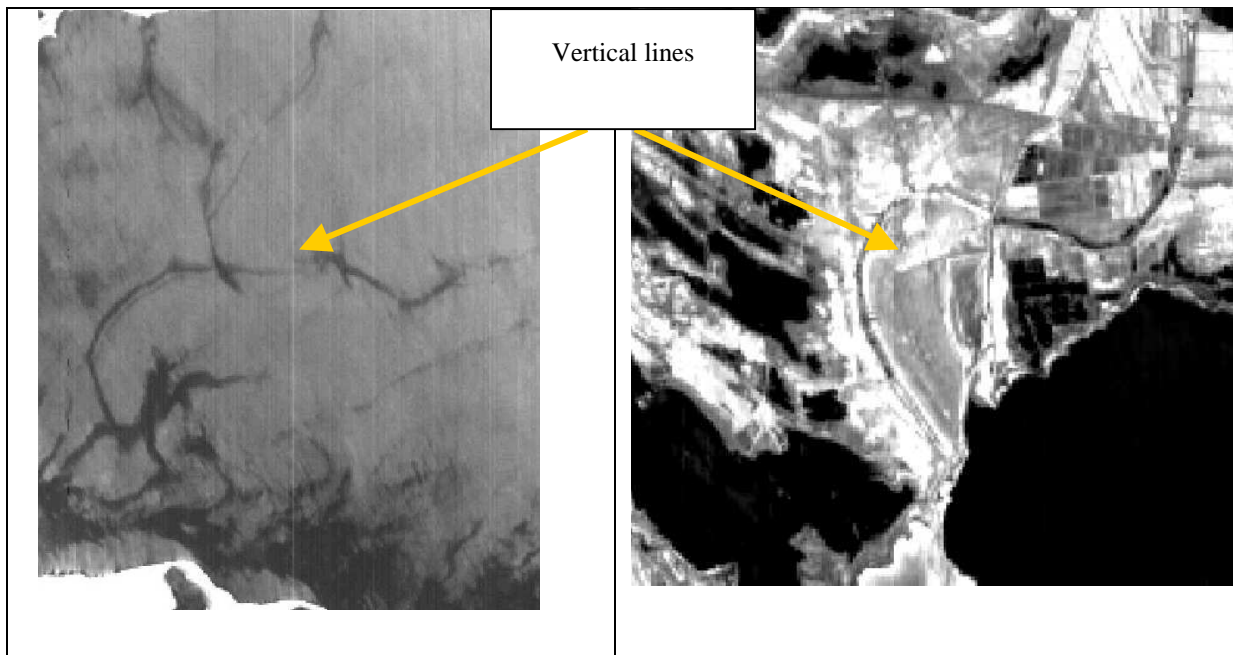


fig. 3 - SPOT 4 - 40492620607041102261I0\_1A - band 4 (MIR) - Vertical lines

Regarding the full resolution windows, SPOT 4 data are more detailed and more contrasted than the LISS 3. This difference is probably due to the resampling pixel size, from 23,5 m to 20 m.



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### A.4.3 Histogram analysis

For the comparison between histograms, three (3) windows are used in IRS LISS 3 and SPOT HRVIR data. The data were acquired during the same month (July), with three (3) years of difference between the scenes, which are the following:

- LISS 3 060725P6023038L0020S3 (25/07/06)
- SPOT 4 00149170047 (25/07/03)

(See next pages)



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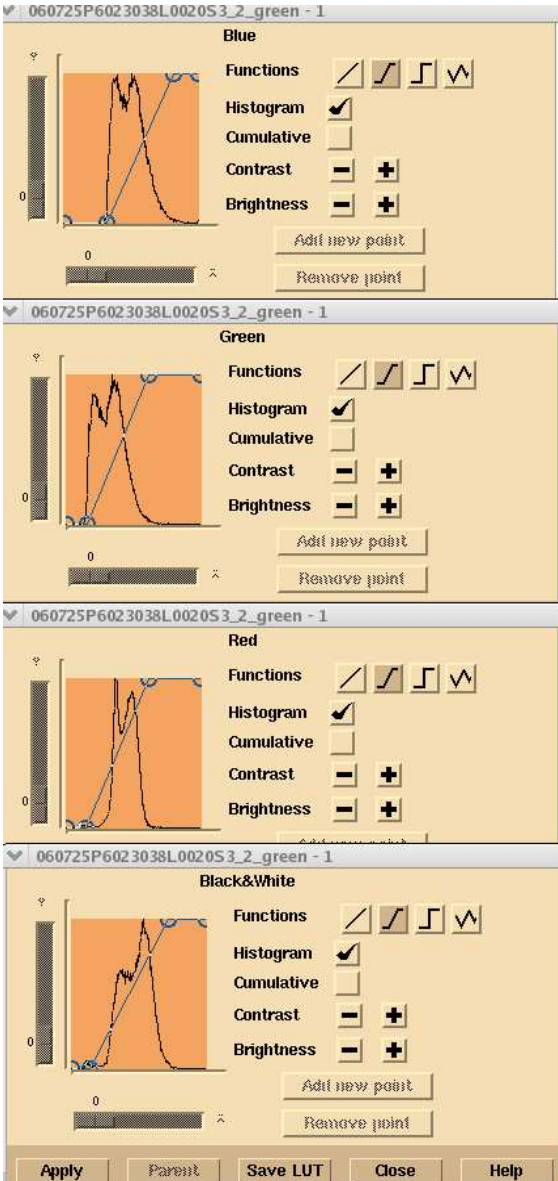
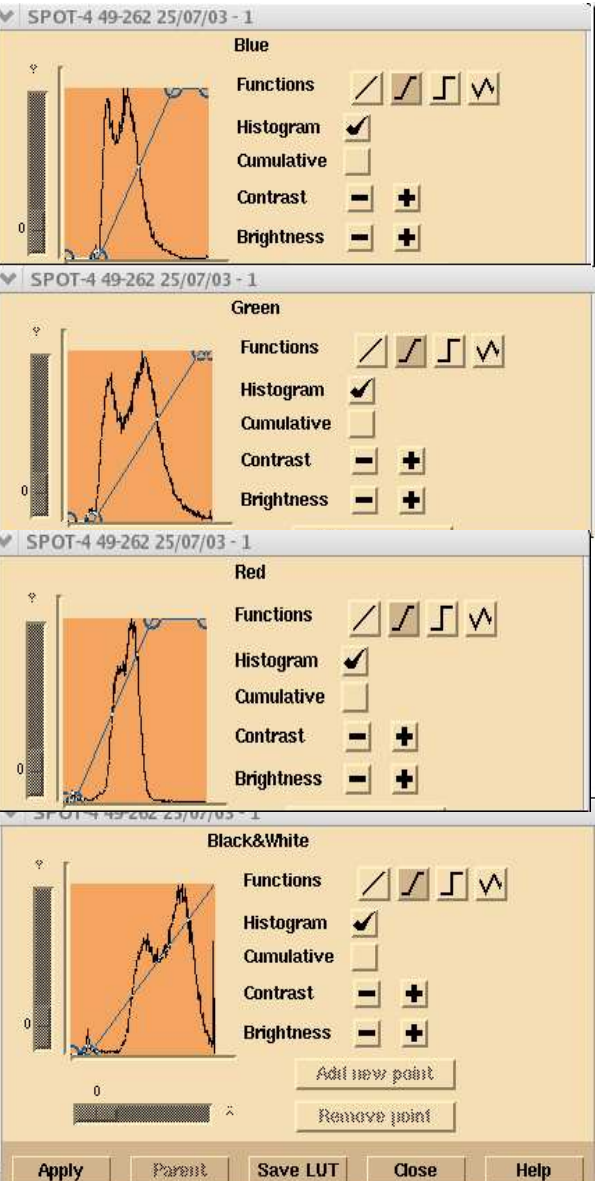
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IRS P6 - LISS 3	SPOT 4 - HRVIR
 <p data-bbox="288 797 705 831">Window 1 – crop fields bd 234 (RGB)</p>	 <p data-bbox="908 797 1324 831">Window 1 – crop fields bd 321 (RGB)</p>
 <p data-bbox="215 842 775 2018">This screenshot shows the color calibration interface for the IRS P6 - LISS 3 image. It features four panels for the Blue, Green, Red, and Black&amp;White channels. Each panel includes a histogram, a set of function icons (linear, gamma, sigmoid, wave), and checkboxes for Histogram, Cumulative, Contrast, and Brightness. The Contrast and Brightness controls are shown as sliders with '+' and '-' signs. Buttons for 'Add new point', 'Remove point', 'Apply', 'Parent', 'Save LUT', 'Close', and 'Help' are visible at the bottom.</p>	 <p data-bbox="817 842 1414 2018">This screenshot shows the color calibration interface for the SPOT 4 - HRVIR image. It features four panels for the Blue, Green, Red, and Black&amp;White channels. Each panel includes a histogram, a set of function icons (linear, gamma, sigmoid, wave), and checkboxes for Histogram, Cumulative, Contrast, and Brightness. The Contrast and Brightness controls are shown as sliders with '+' and '-' signs. Buttons for 'Add new point', 'Remove point', 'Apply', 'Parent', 'Save LUT', 'Close', and 'Help' are visible at the bottom.</p>

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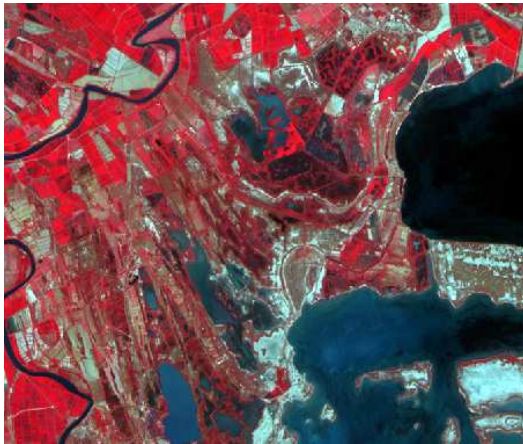
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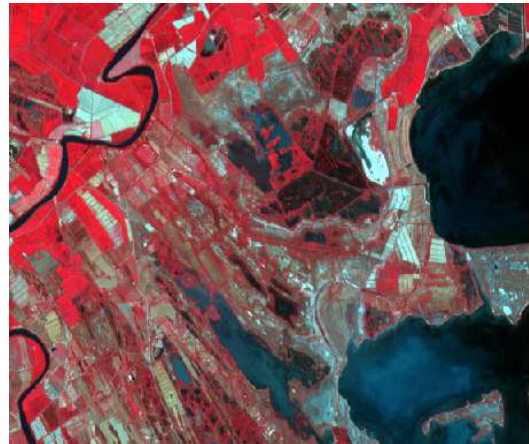
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window 2 – water area bd 234 (RGB)



window 2 – water area bd 321 (RGB)

060725P6023038L0020S3\_2\_green - 1

**Blue**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

060725P6023038L0020S3\_2\_green - 1

**Green**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

060725P6023038L0020S3\_2\_green - 1

**Red**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

060725P6023038L0020S3\_2\_green - 1

**Black&White**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

Add new point

Remove point

Apply Parent Save LUT Close Help

SPOT-4 49-262 25/07/03 - 1

**Blue**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

SPOT-4 49-262 25/07/03 - 1

**Green**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

SPOT-4 49-262 25/07/03 - 1

**Red**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

SPOT-4 49-262 25/07/03 - 1

**Black&White**

Functions

Histogram

Cumulative

Contrast - +

Brightness - +

Add new point

Remove point

Apply Parent Save LUT Close Help



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window 3 – urban area – various spectral behavior



window 3 – urban area – various spectral behavior

060725P6023038L0020S3\_2\_green - 1

**Blue**

Functions

Histogram

Cumulative

Contrast

Brightness

060725P6023038L0020S3\_2\_green - 1

**Green**

Functions

Histogram

Cumulative

Contrast

Brightness

060725P6023038L0020S3\_2\_green - 1

**Red**

Functions

Histogram

Cumulative

Contrast

Brightness

060725P6023038L0020S3\_2\_green - 1

**Black&White**

Functions

Histogram

Cumulative

Contrast

Brightness

Add new point

Remove point

Apply Parent Save LUT Close Help

SPOT-4 49-262 25/07/03 - 1

**Blue**

Functions

Histogram

Cumulative

Contrast

Brightness

SPOT-4 49-262 25/07/03 - 1

**Green**

Functions

Histogram

Cumulative

Contrast

Brightness

SPOT-4 49-262 25/07/03 - 1

**Red**

Functions

Histogram

Cumulative

Contrast

Brightness

SPOT-4 49-262 25/07/03 - 1

**Black&White**

Functions

Histogram

Cumulative

Contrast

Brightness

Add new point

Remove point

Apply Parent Save LUT Close Help



In general, for the four (4) bands, the histogram shows a good form and the behavior is the same for each channel of both instruments. However SPOT histogram seems to be larger.

We notice that histograms for SPOT 4 data remains mainly more centered than the LISS 3 ones. We also notice some saturation in SPOT 4 SWIR band.

Due to the few spectral difference, the spectral bands between the two sensors can be associated like the following :

<u>IRS LISS 3</u>		<u>SPOT 4 HRVIR</u>
B2 (green)	➔	B1 (green)
B3 (red)	➔	B2 (red)
B4 (nir)	➔	B3 (nir)
B5 (swir)	➔	B4 (swir)

*table 6 - Spectral bands matching*

#### **A.4.4 Spectral resolution**

Spectral resolution describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.

IRS P6 spectral bands are finer than the SPOT 4 ones. Thus, it can represent features of various colours based on their reflectance in each of these distinct wavelength ranges.

#### **A.5 Geometry**

The scenes are from different processing levels that means the comparison of the absolute location cannot be done directly.

IRS P6 data are in level 1B according to euomap. These data are geocoded (North oriented) in UTM 31 projection, with a Cubic Convolution resampling method.

SPOT 4 data are in level 1A. The processing for level 1A is only radiometric correction of distortions due to differences in sensitivity of the elementary detectors of the viewing instrument. Intended for users who wish to do their own geometric image processing.



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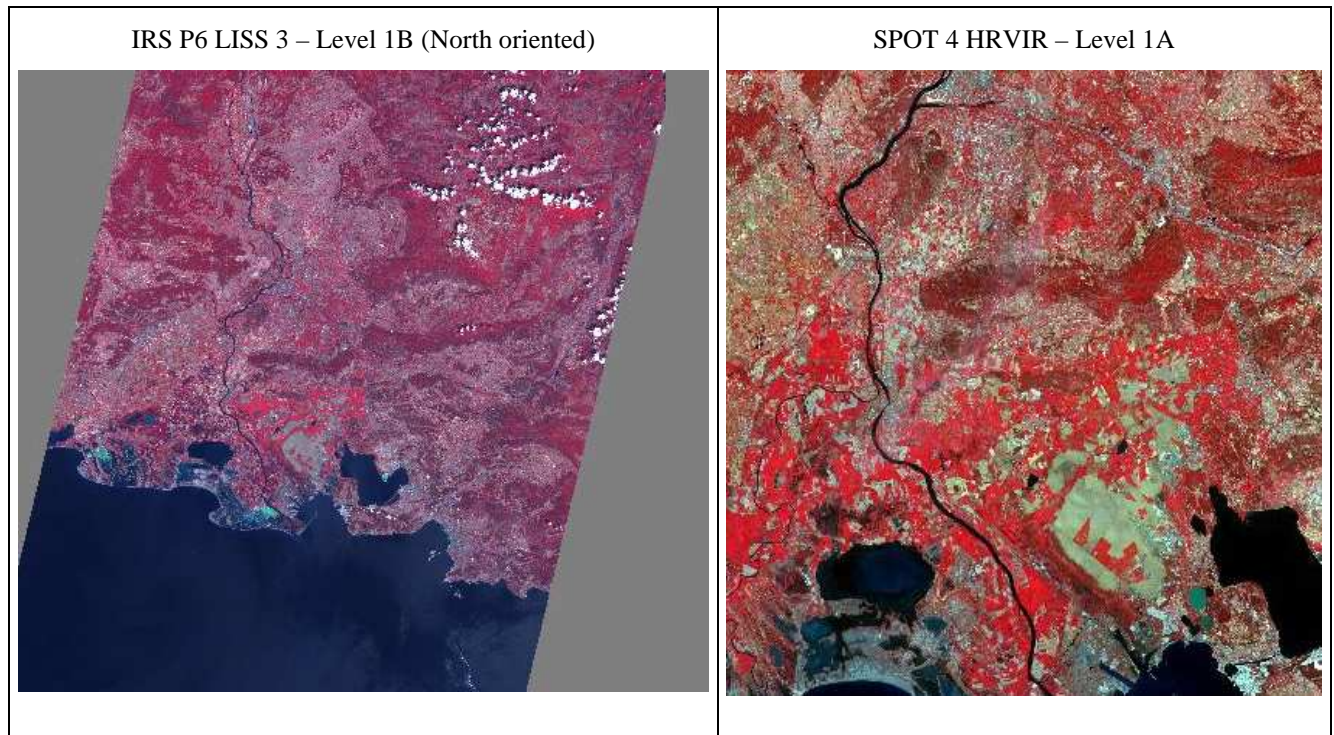
IRS P6 - SPOT 4 Comparison - First Assessment

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*fig. 4 - IRS P6 and SPOT 4 data processing levels*

### A.5.1 Absolute Location Control

For achieving the absolute location control, the SPOT 4 data were geocoded without taking GCP, in the same projection and resampling method (UTM 31, CC) as IRS P6.

The following SPOT data were geocoded.

- 00149170047 (25/07/03)
- 40492620607041102261I0\_1A\_NETWORK (04/07/06)

The topographic maps in scale about 1:25000 were used as reference data to assess the absolute location accuracy.



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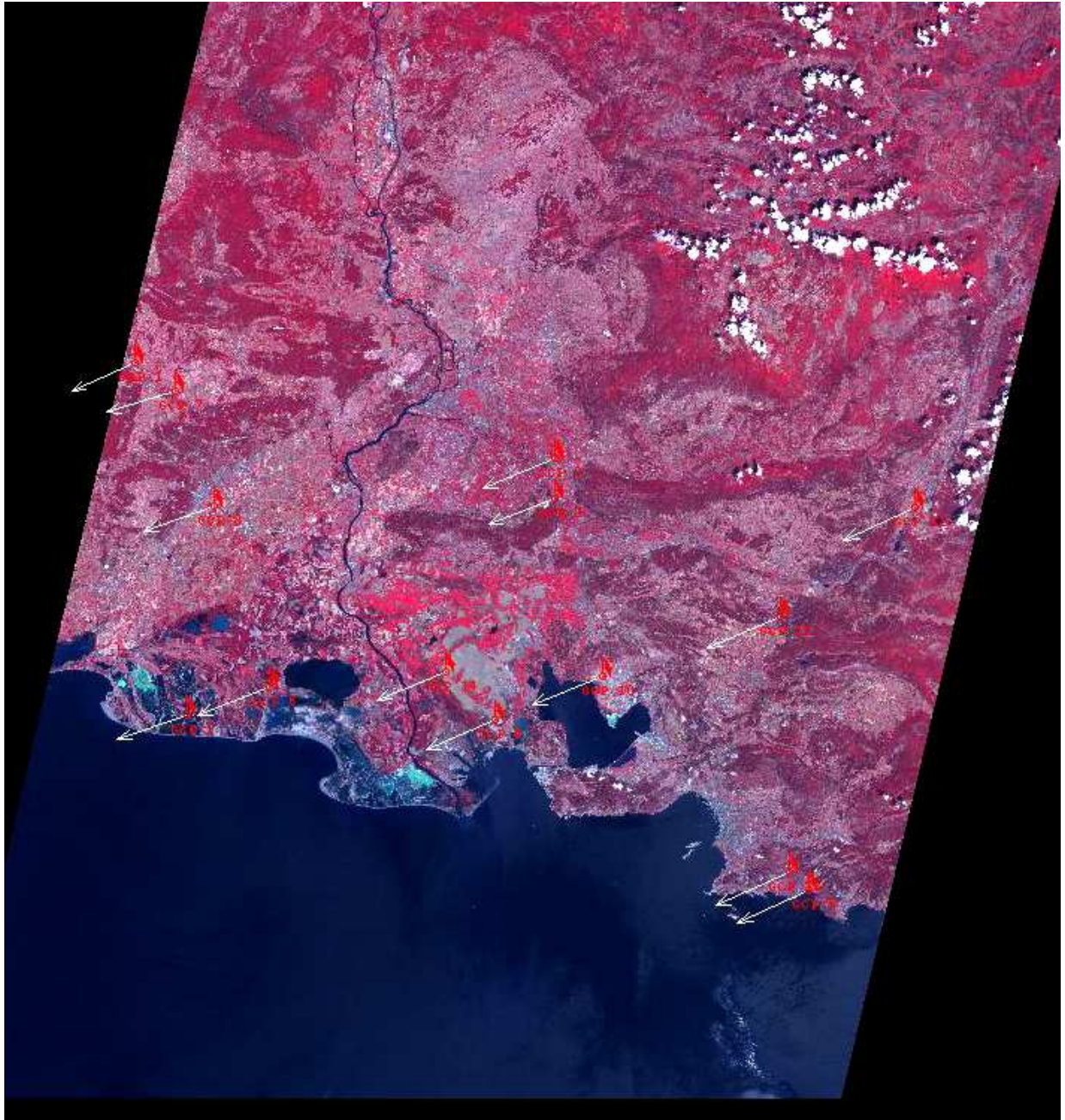
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*fig. 5 - IRS P6 - 060701P6023038L0020S3 - Errors vectorFields (x20)*



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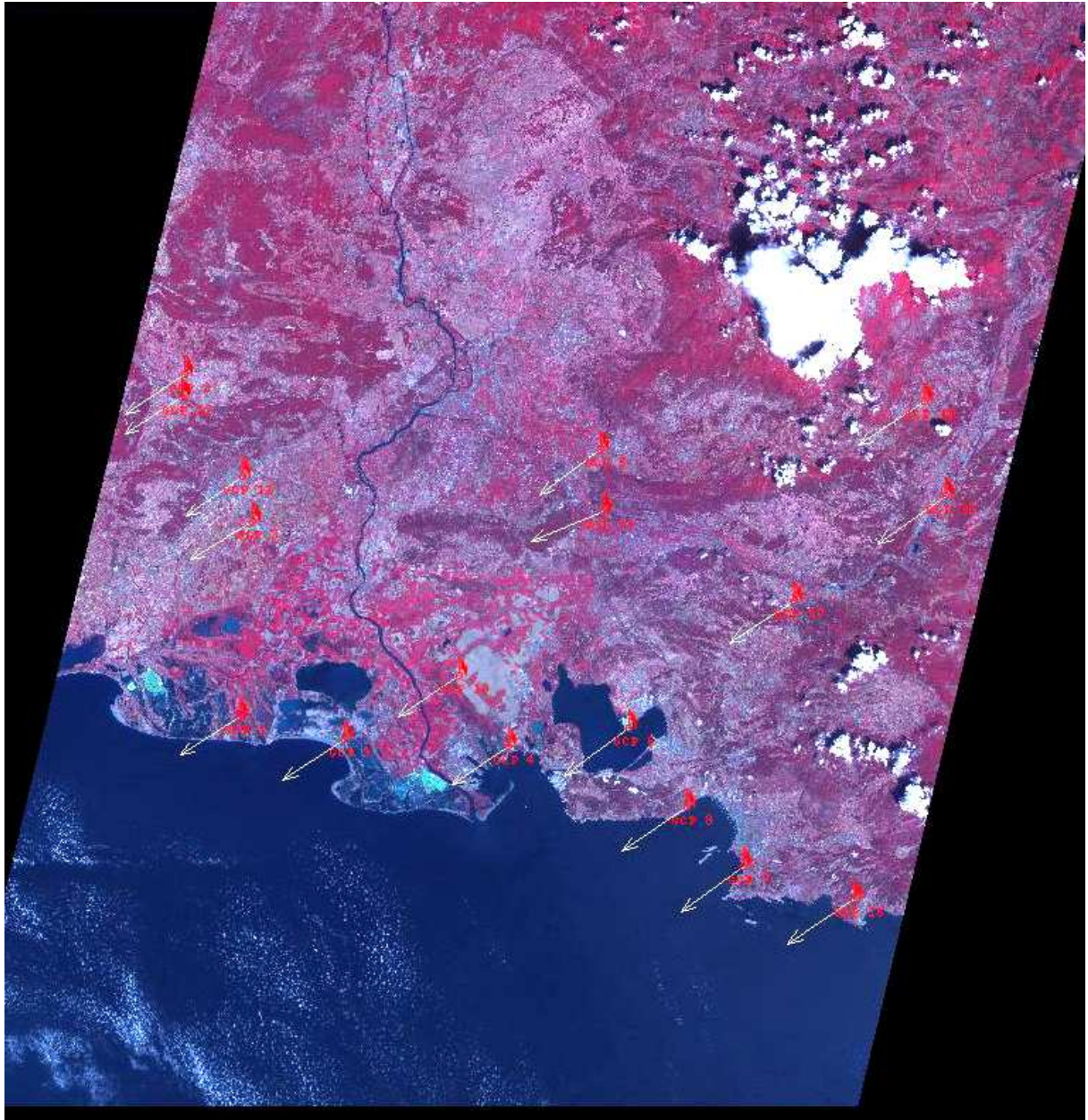


fig. 6 - IRS P6 - 060725P6023038L0020S3 - Error Vector Fields (x20)



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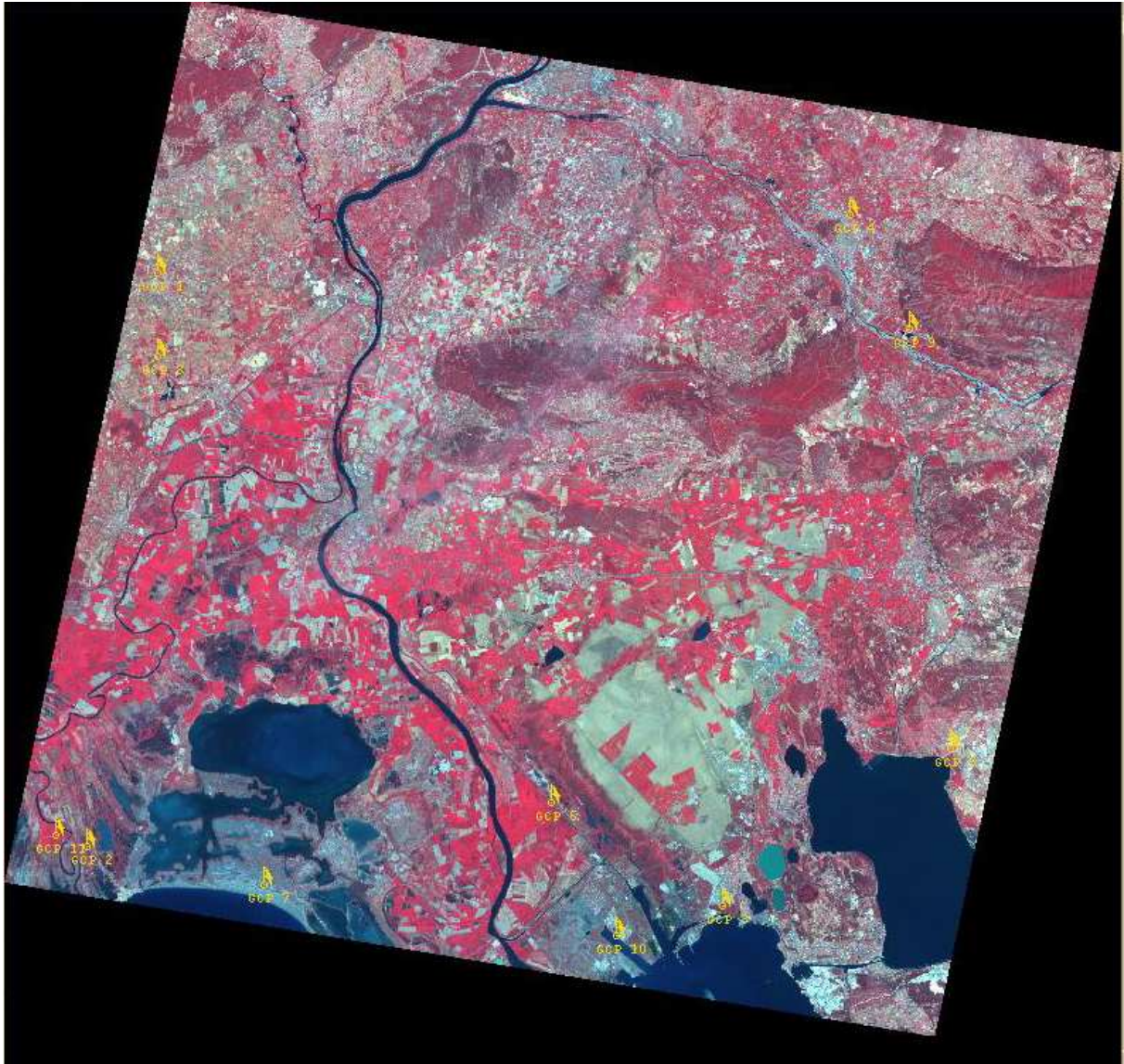
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*fig. 7 - SPOT 4 - 00149170047- Error Vector Fields (x20)*



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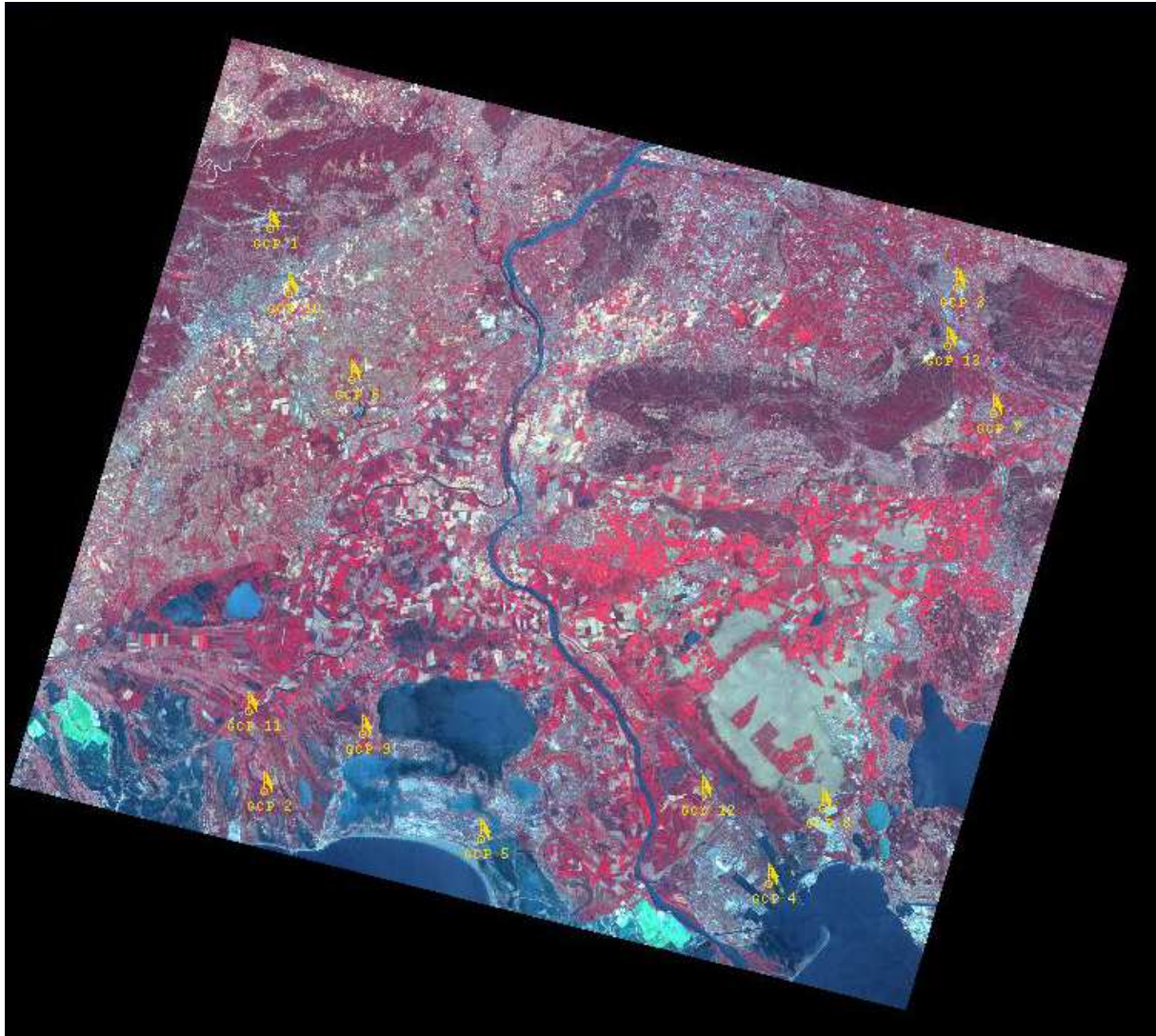


fig. 8 - SPOT 4 - 4049262060704110226110\_1A - Error Vector Fields (x20)



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*fig. 9 - IRS P6 LISS3 (white) - SPOT 4 HRVIR (red) - Vector boundaries*



### A.5.2 Results

The absolute location results magnify an important across-track shift for the LISS3 data. This shift is about 600 meters. According to the direction of the vector error fields, this kind of error could be due to ephemeris and attitude precision, like a combination of the time and the roll of satellite.

The SPOT data are correctly localised and the RMS lower than the specification's value. It is reminded that these values are obtained without ground reference point (GRP) for the geocoding.

	<b>RMS X error</b>	<b>RMS Y error</b>	<b>RMS</b>	<b>Mean</b>	<b>Number of GCP</b>
<b>IRS P6 – LISS3 - 060701P6023038L0020S3</b>	573.340 m	231.741 m	<b>618.404 m</b>	617.794 m	14
<b>IRS P6 – LISS3- 060725P6023038L0020S3</b>	510.623 m	335.537 m	<b>611.000 m</b>	610.003 m	14
<b>SPOT 4 - 00149170047</b>	17.273 m	15.715 m	<b>23.352 m</b>	19.918 m	11
<b>SPOT 4 - 40492620607041102261I0_1A</b>	34.756 m	20.685 m	<b>40.445 m</b>	30.712 m	13

table 7 - Geometric absolute location control of IRS and SPOT data

### A.5.3 Interband alignment

The interband alignment test was performed by QUISS software. No interband alignment error was detected. All bands of the IRS P6 LISS3 data are perfectly superimposed. QUISS interband report is attached to this document.

Note: this test was applied on the three (3) first bands only.

### A.5.4 Striping

The striping test was performed by QUISS software. No striping was detected on the IRS P6 data. The results is attached to this document.

### A.5.5 IRS P6 data location Improvement

To improve the IRS P6 LISS 3 data location, the data was geocoded taking into account the geometric camera parameters given in the metadata file called RPC (rational polynomial coefficient). Some ground control points were taken on the topographic maps.

The geometric quality control after the geocoding gives the best results (animated GIF files are provided in attachment to this document). The table below gives the results compared to the topographic maps and the SPOT geocoded data. The geocoded IRS P6 scene is : 060701P6023038L0020S3

<b>IRS P6 LISS3</b>	<b>RMS X error</b>	<b>RMS Y error</b>	<b>RMS</b>	<b>Mean</b>	<b>Number of GCP</b>
<b>vs SPOT data</b>	13.776 m	9.022 m	<b>16.467 m</b>	15.244 m	11
<b>vs MAPS</b>	17.983 m	8.087 m	<b>19.718 m</b>	17.879 m	11

table 8 - Geocoded IRS data, geometric absolute and relative location control