# SPOT 5 - HRS GEOMETRIC PERFORMANCE

1 – IGN presentation

2 – Method used to enhance the SPOT 5 – HRS localization performance

# Reference3D ® project

Since 2002 IGN in collaboration with SPOT Image is engaged in the elaboration of a global earth coverage in orthoimage (5m pixel) and DEM DTED2 level using the HRS instrument on SPOT5 :

- Ref3D-V1 : 30 $MKm^2$, localization 15m (for 90%)
- Ref3D Alpha : 70 $MKm^2$, localization « best effort » (but ≤15m)
- Ref3D-V2 : 50 $MKm^2$ localization 10m (for 90%)

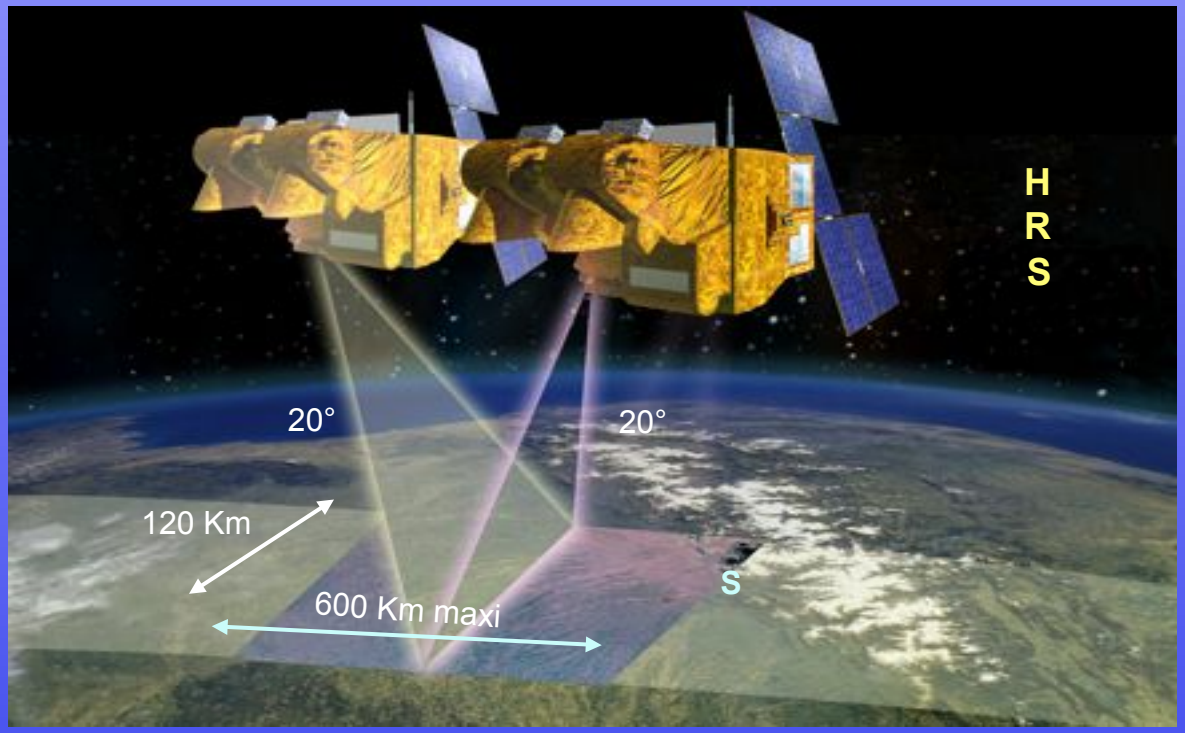
The localization requirements implies to have an efficient follow-up of the satellite through image acquisition on test sites (developed after)

SPIRIT project DEM and orthoimage were produced using the experience acquired on the Ref3D project

# HRS instrument onboard SPOT5

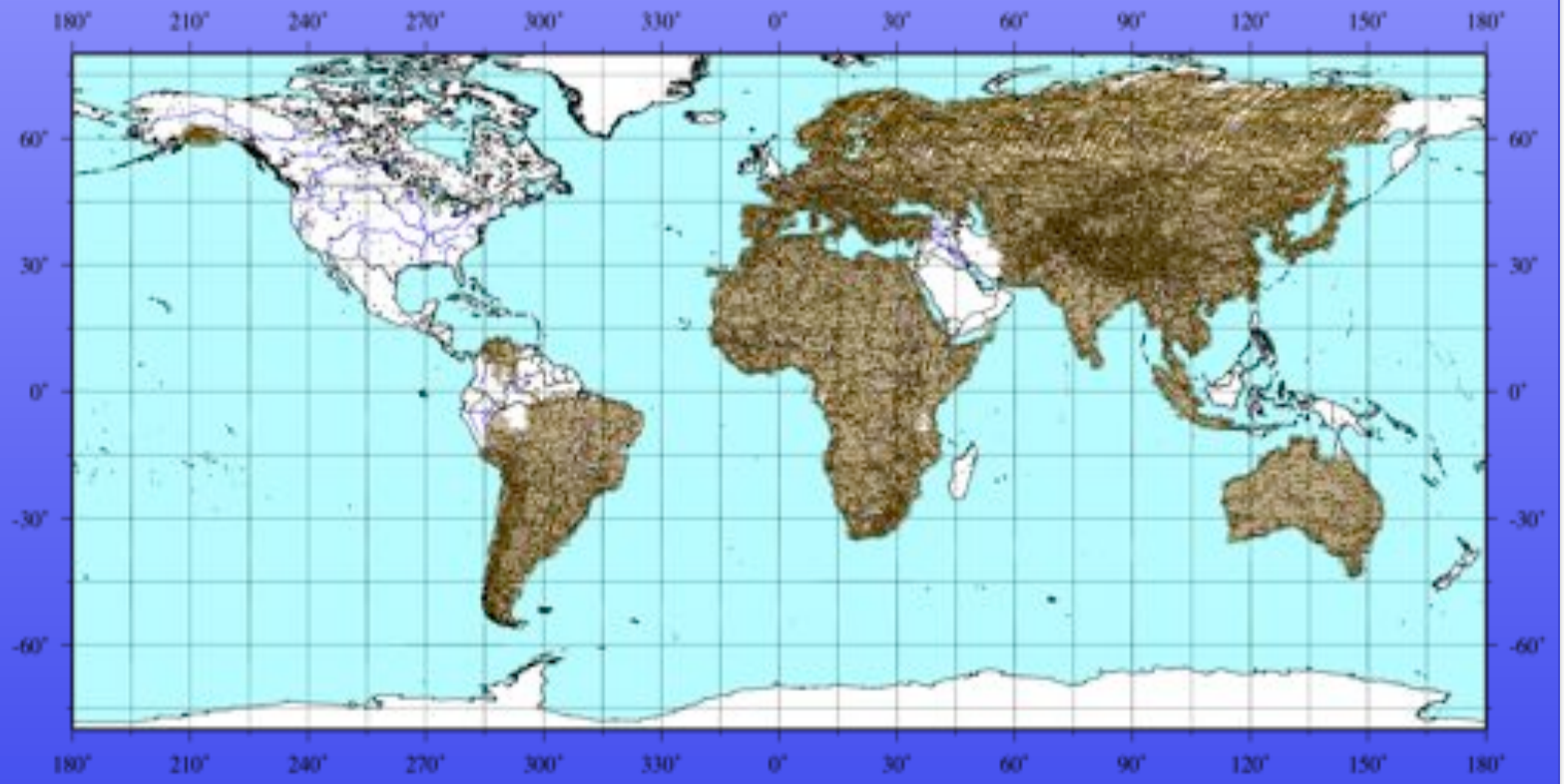
HRS instrument :

- Panchromatic band
- Line sampling 10 m
- Column sampling 5 m
- Swath 120 km
- Orbital cycle : 26 days
- B/H : 0.8
- Stereo strip: 600 km max



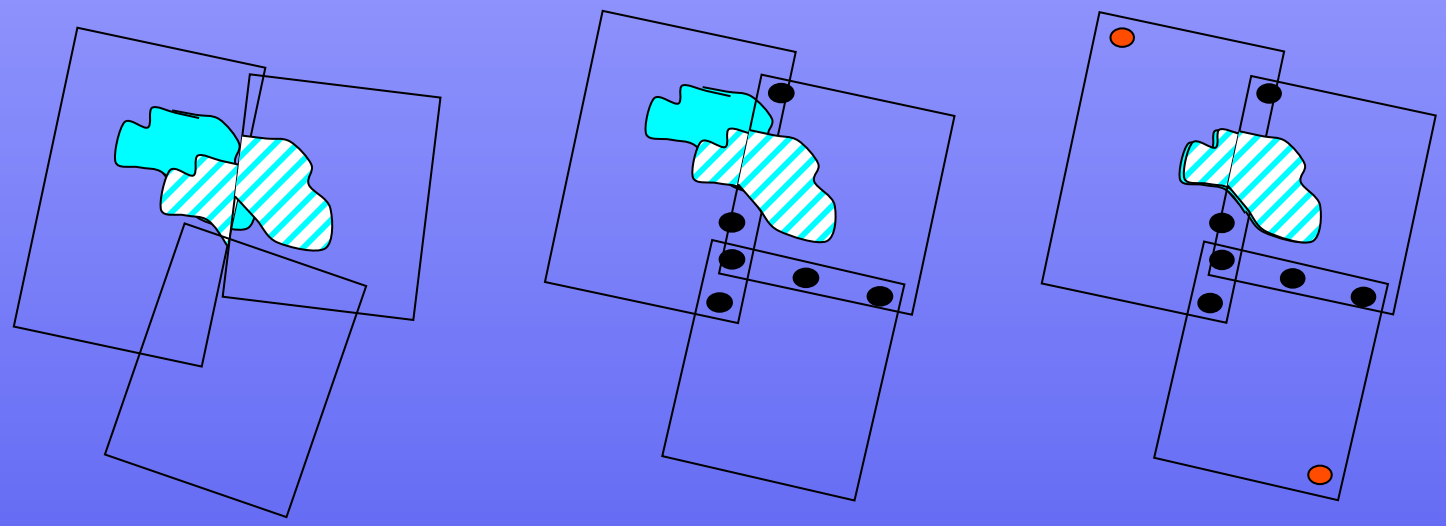

Each image line acquired twice
from the same orbit with 90 seconds interval

# AREA PROCESSED SINCE 2007




Processing wide areas allows to get an homogeneous set of orthoimages keeping in mind the necessary localization criterias of 10m final precision (≈8m out from the spacetriangulation process)

# Tie points and Ground Control Points (GCPs)



Before spacetriangulation :

The images location is computed using only the ancillary data.

Using GCPs :

The localization coherence between the images is insured using tie points. Some few additional GCPs allow to globally shift the set of images to the real terrain coordinates.

Using tie points:

Identifying similar details on different images allow to insure the localization coherence between the images but don't insure the accuracy (image of the lake shifted relatively to the terrain).

# Ancillary data and initial localization of the satellite images (example of SPOT5-HRS)

- Ancillary data evaluation

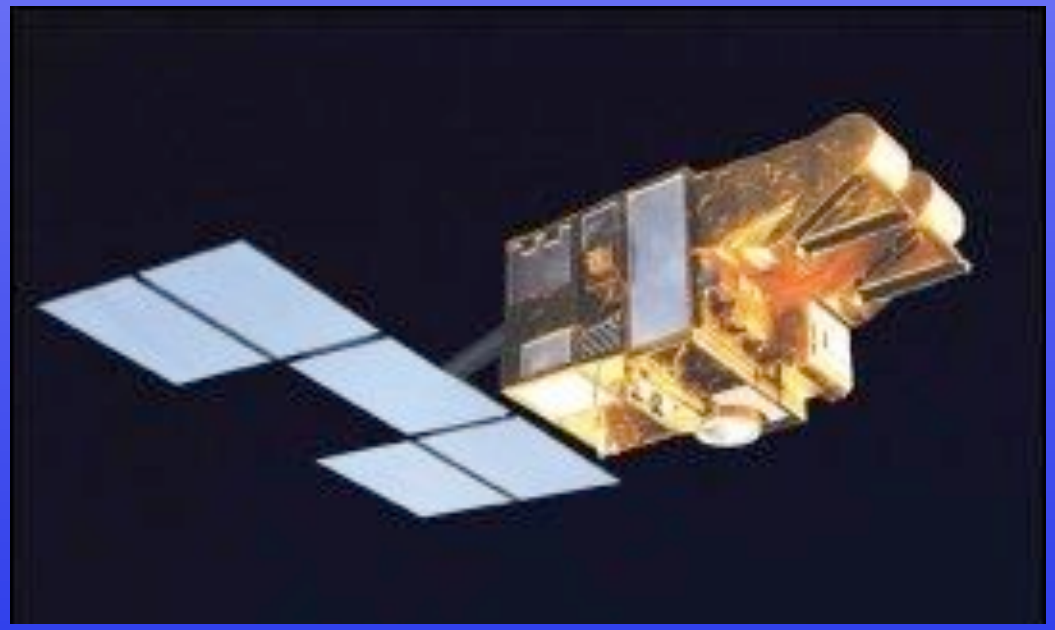
A good knowledge of the satellite and instrument used is necessary to choose the parameters to be estimated and their weight and the ancillary data must be evaluated in terms of precision and reliability.

  - Orbit : < 1m for Spot 5
  - Satellite orientation (attitude angles) : around 20 µradian precision for Spot 5 (16m on the ground)
  - Orientation of the telescope relatively to the satellite
  - Shape of the CCD : < 1/10$^{th}$ pixel for Spot 5

- Systematic errors detection and evaluation
  - Slowly variable perturbating elements
  - Instruments biases and their stability in time

# Classical perturbating elements

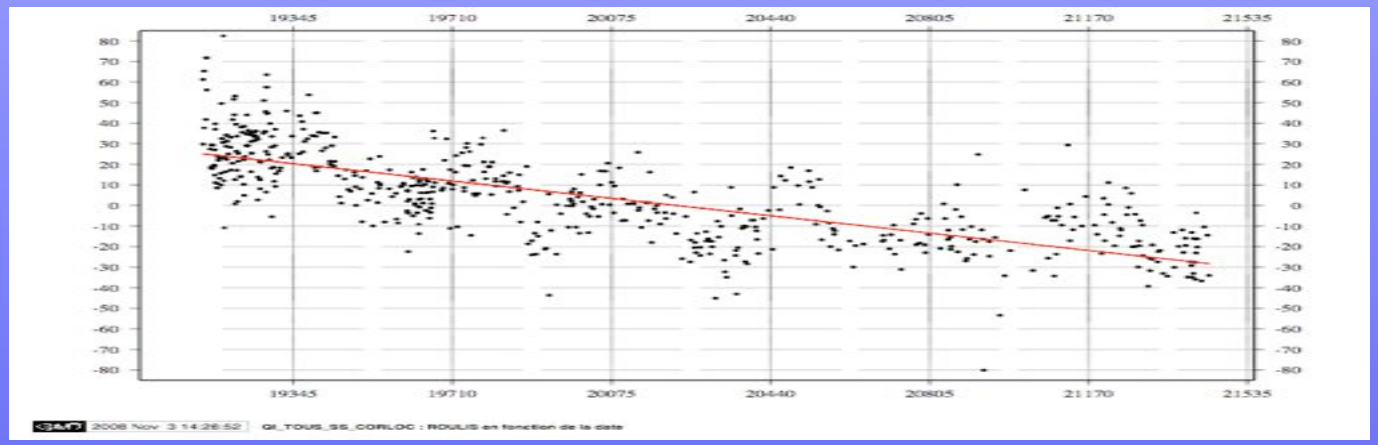
- Ageing : after launch the satellite structure distorts slowly until stabilization.
- Regular distortions on each orbit due to the strong thermal variations undergone by the satellite.
- Seasonal variations.

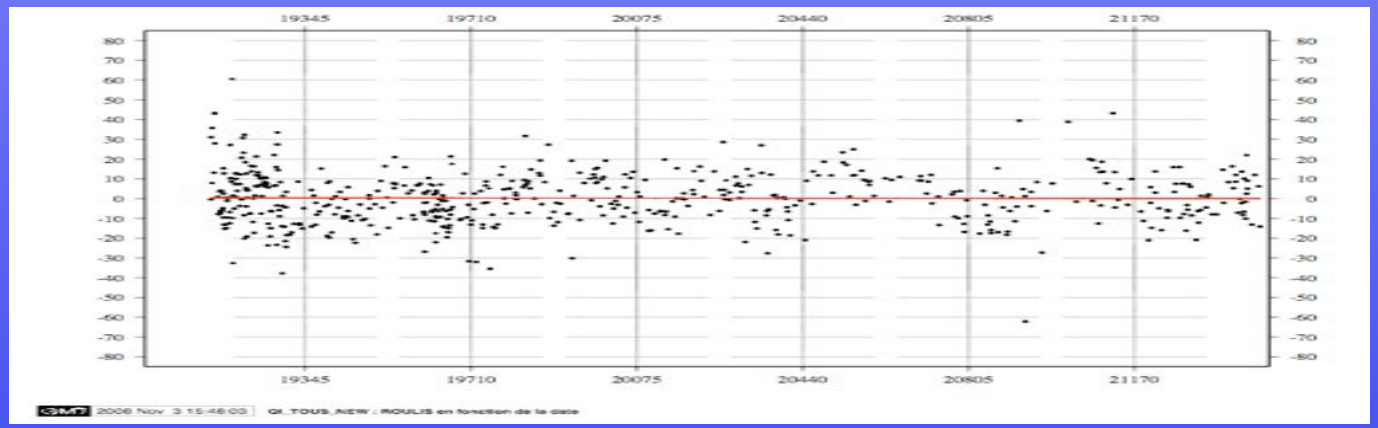


# Calibration sites used for instruments perturbation detection

Distribution of the calibration sites in the world. Blue points in the Middle-East site represent the GCPs groups available for the adjustment

# Perturbation example on Spot 5




Roll component

The cross track localization error depends on the image date. We notice :

- trend (≈ 8 µrad/year)
- seasonal variation (≈ 40 µrad crest with crest)

Conclusion

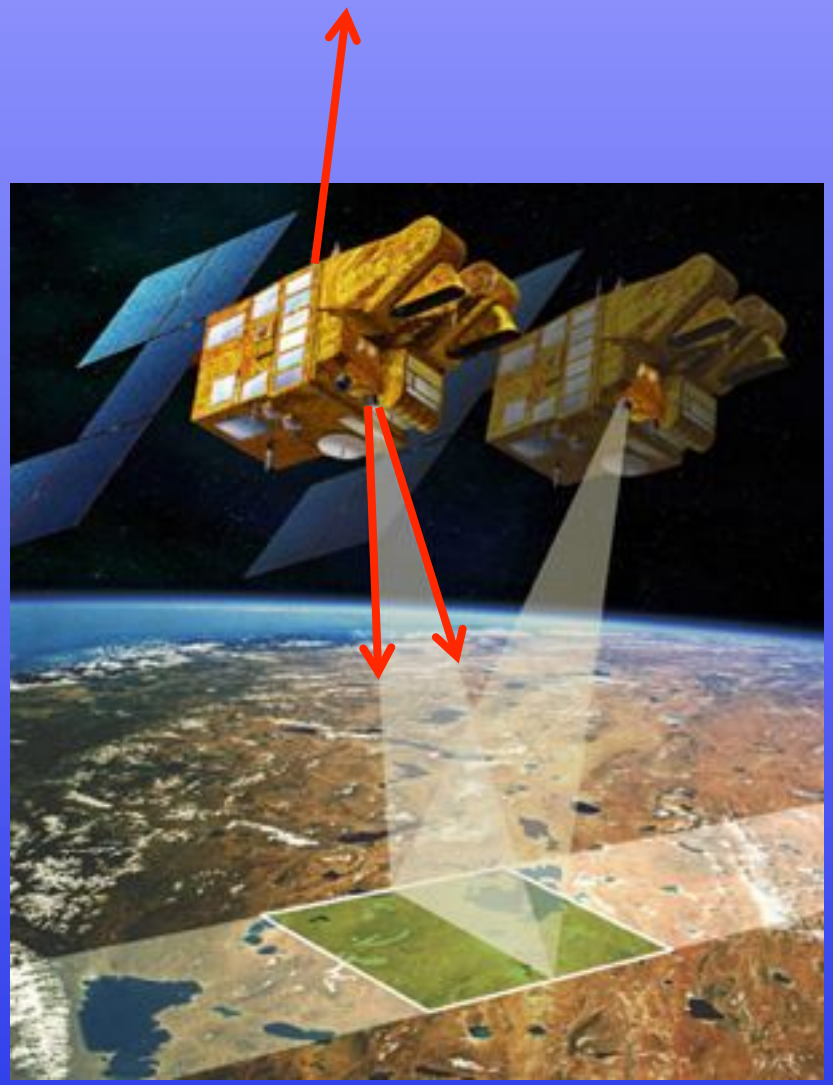
If the thermal variations are anticipated (during construction) and if the residual disturbances are correctly modeled then we minimize the number of necessary GCPs to enhance the localization precision of the images.

# The global parameters and their influence : Example of the sensor line scale 1/3

<u>Measures performed before launch and refined during the commissioning phase :</u>

The angles between the extreme viewing directions and the axis of the stellar sensor (combined with the sensor line shape) will provide the position on earth of each image pixel. The sensor line scale is the angle between the two extreme viewing directions.

These measures can be estimated for every image, or fixed as in the case of Spot5.

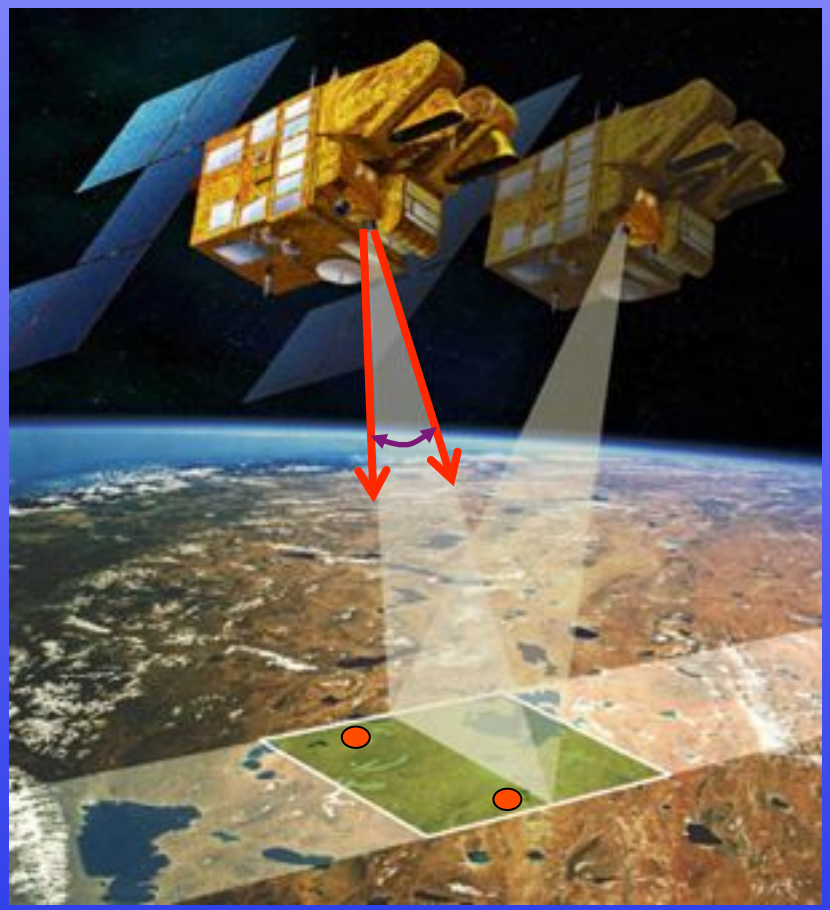


# The global parameters and their influence : Example of the sensor line scale 2/3

If we have to estimate the sensor line scale for each image, it is necessary to have GCPs in the east and the west extremities of the image.

If this value is known and stable in the time, this angle will not be estimated and one GCP will be enough :

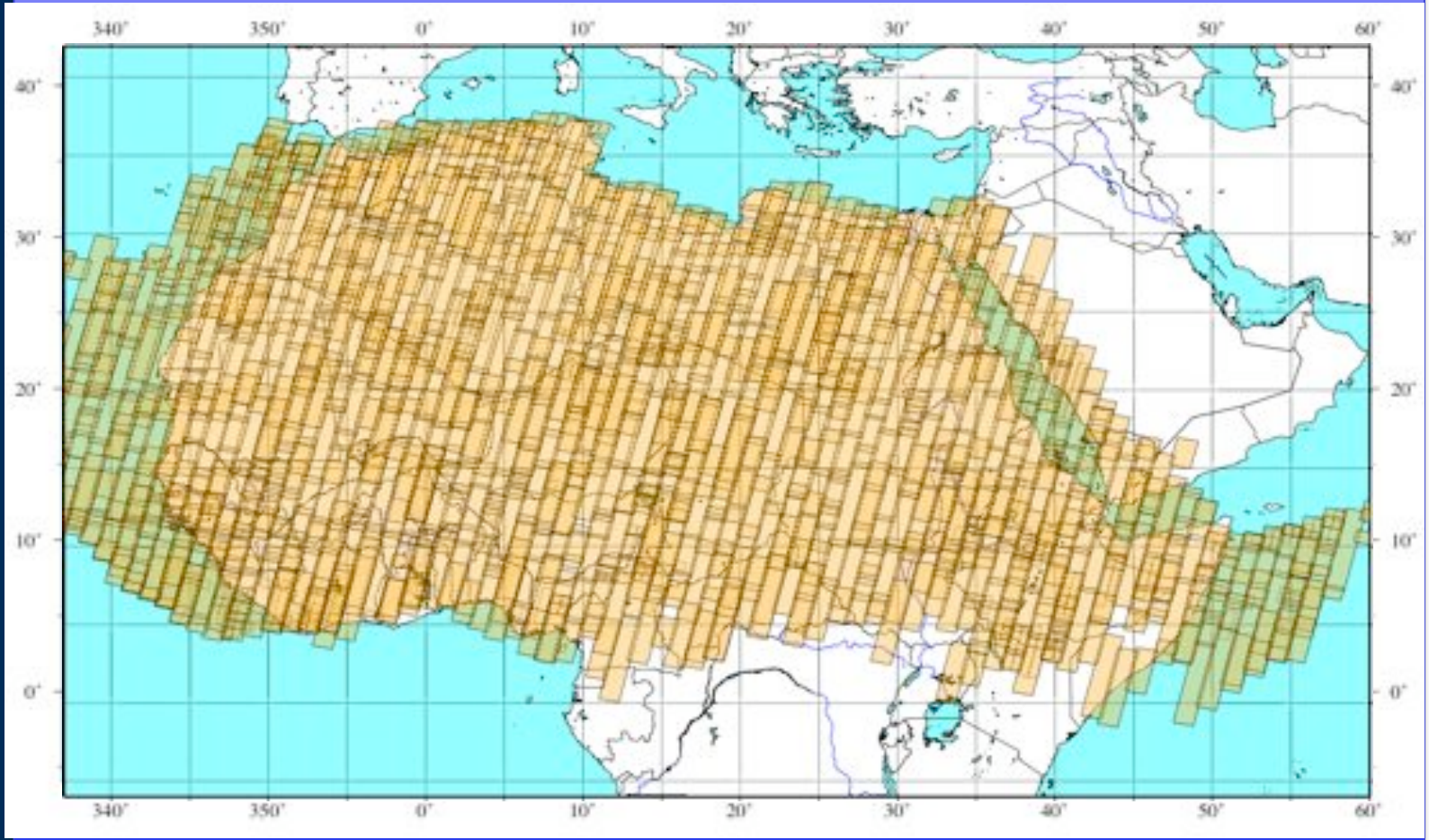
- to shift the image by a translation on the terrain coordinates
- or to shift a block of images connected with tie points



# The global parameters and their influence : Example of the sensor line scale 3/3

In the case of numerous images connected between them by tie points, an error of magnification will act on the global extension of the site

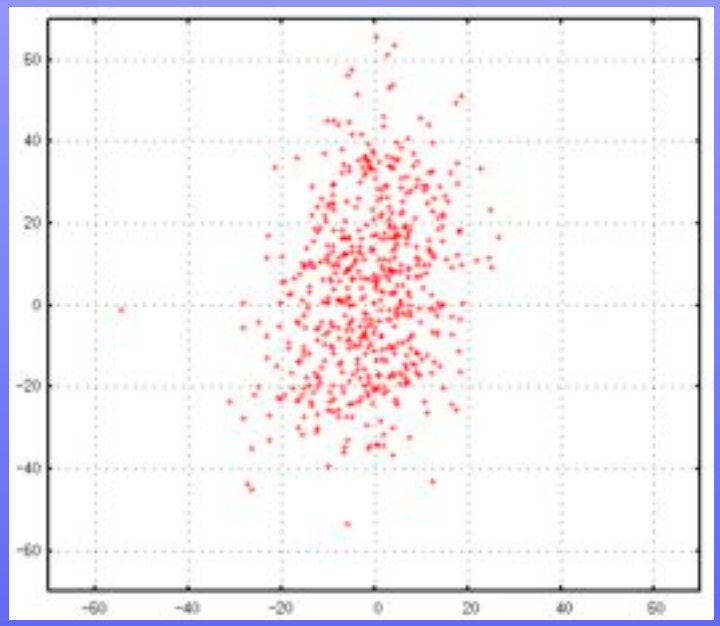
*1/10th pixel per image → +/- 45 m on North Africa extend!*

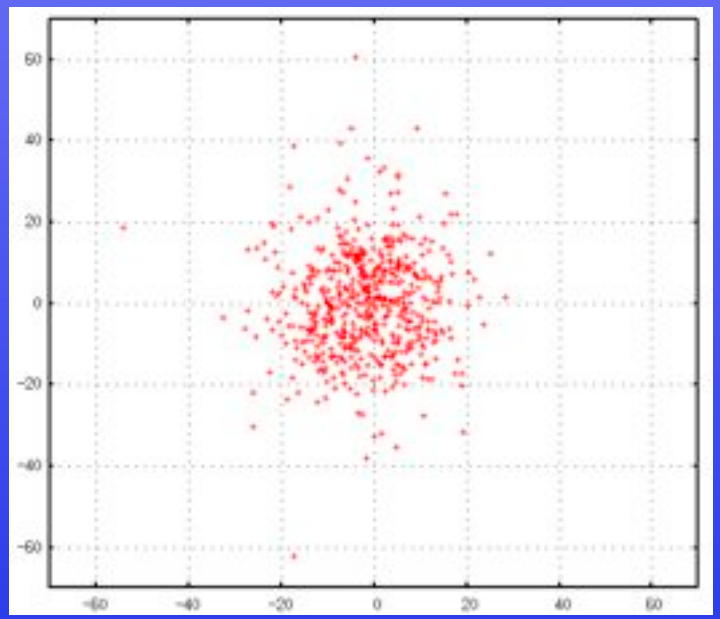


# Instrument calibration results

After adjustment of the global parameters and removal of the ageing and seasonal variations the final HRS localization performance of HRS images is 20 µradian as shown in the lower diagram here.

This allows to insure a quality of localization even when no GCPs are available and to minimize the number of GCPs necessary when only some are available.



# SPIRIT spacetriangulation process

For the SPIRIT project the first idea was to make a global spacetriangulation model for the whole images acquired.
Several problems appeared

- Some areas had no images : impossible to join
- Many cloudy images
- Images from different dates impossible to join if the common area is on glaciers

Finally the process was performed using little independent areas

Two DEMs are created for each stereopair

- One with parameters optimized for the flat areas
- Second one with parameters dedicated to mountain areas

The difference in the parameters is mostly a constraint on the slope for adjacent pixels used during the correlation process.

# SPIRIT DEM

Flat area parameters

Mount