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Automatic geo-registration of satellite imagery

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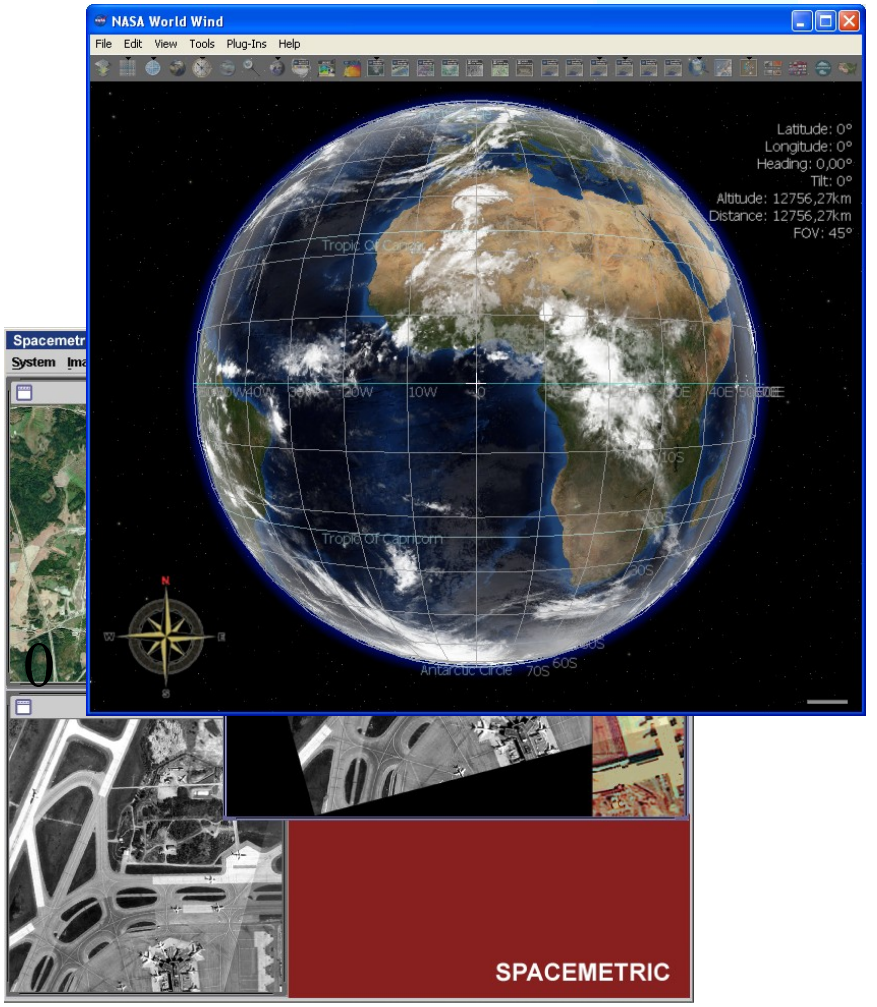
Keystone Image Server

Keystone is an automatic system for archiving, cataloguing and processing digital images from satellites and other digital sensors. Image data can be stored in Keystone and accessed in a uniform way, either using web-based interfaces for overview or as full resolution products.

Keystone minimises manual intervention in the image supply process and significantly shortens image delivery times. Users interact with the system in a geographically oriented, map-based view.



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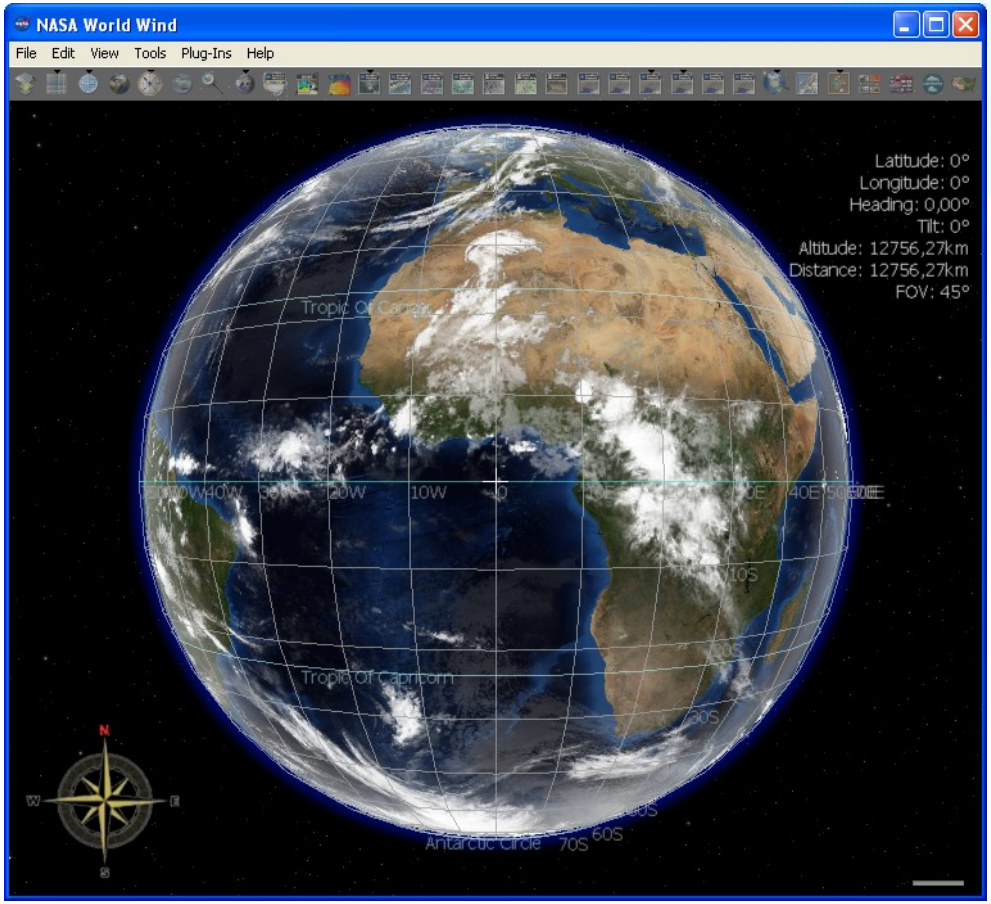
Keystone: OGC standards

- WMS 1.3
- CSW 2.0



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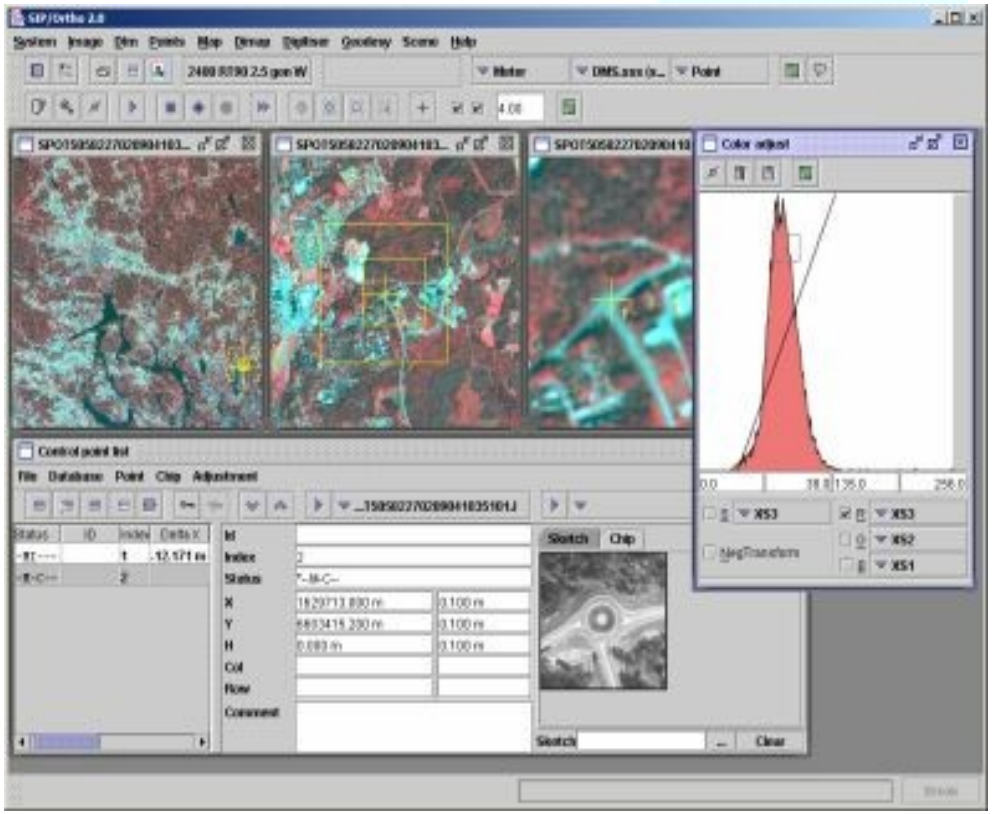
Keystone workstation

Keystone workstation is an integrated satellite orthoimage production suite. It provides an expandable production capability for the latest satellite sensors that uses rigourous photogrammetric methods to give high-accuracy image products at low cost.

Keystone workstation includes image data I/O, DTM import, model adjustment, image rectification, and comprehensive tools for the creation and management of Ground Control Points.



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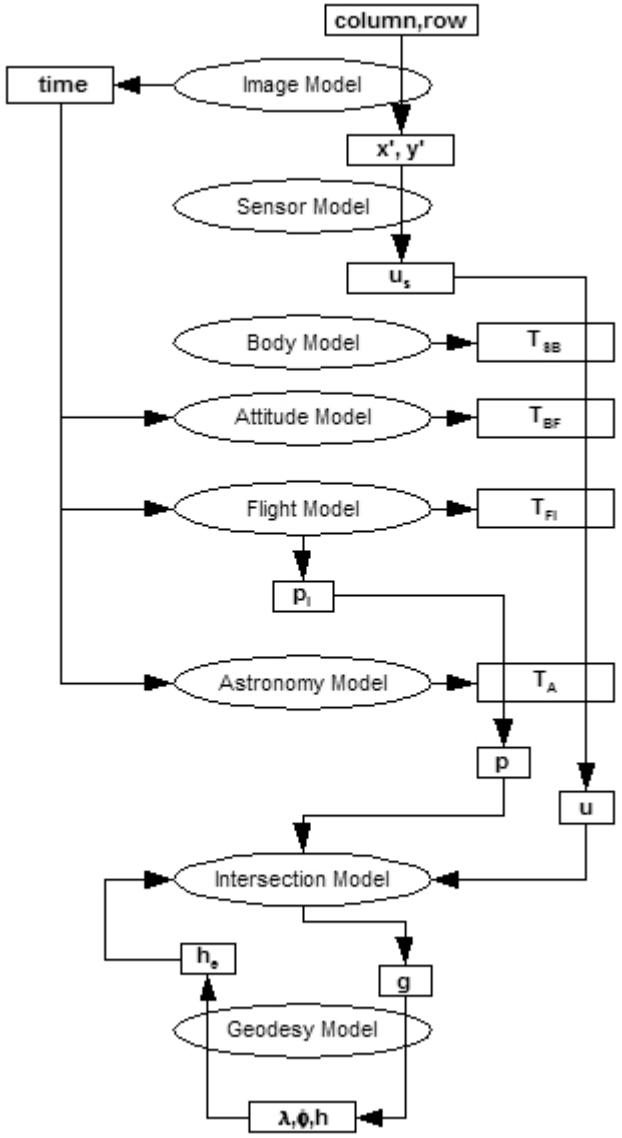
Analytical models

- Highest possible geometrical accuracy for given input data
- Stable solution also with very few control points



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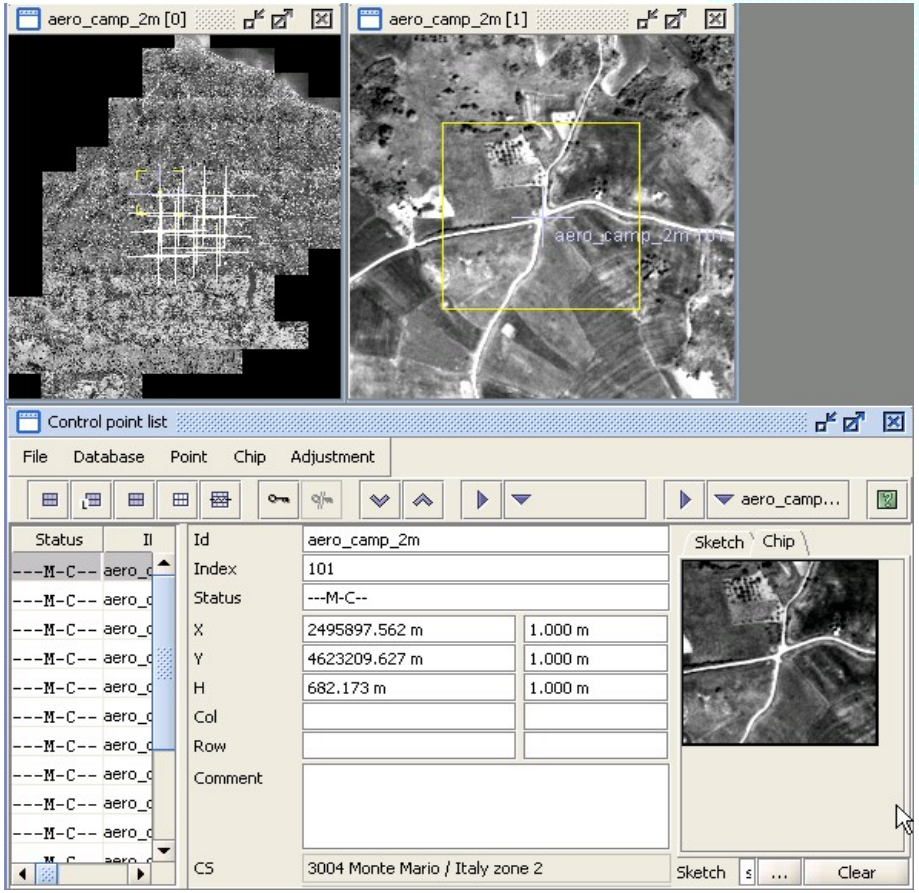
Semi-automatic approach

- Manual selection of GCP's in reference imagery
- Storage of GCP's and chips in a database
- Automatic retrieval of GCP's based on geographical queries
- Positioning of chips in image by correlation



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Semi-automatic approach (cont.)

Advantages

- Possible to select only chips that have features that perform well in correlation
- Less affected by gross errors in correlation
- Faster correlation as fewer number of chips are used

Dis-advantages

- Requires a large manual work to populate the database
- Risk for too low density in chip distribution
- Different types of target images require chips of different resolution and spectral bands
- “Pull-in” range can be to large

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Case study: NLR Military reconnaissance

- Automated reception and processing of Eros and Spot 4
- NATO HRF-HQ Allied Warrior exercise November 2004

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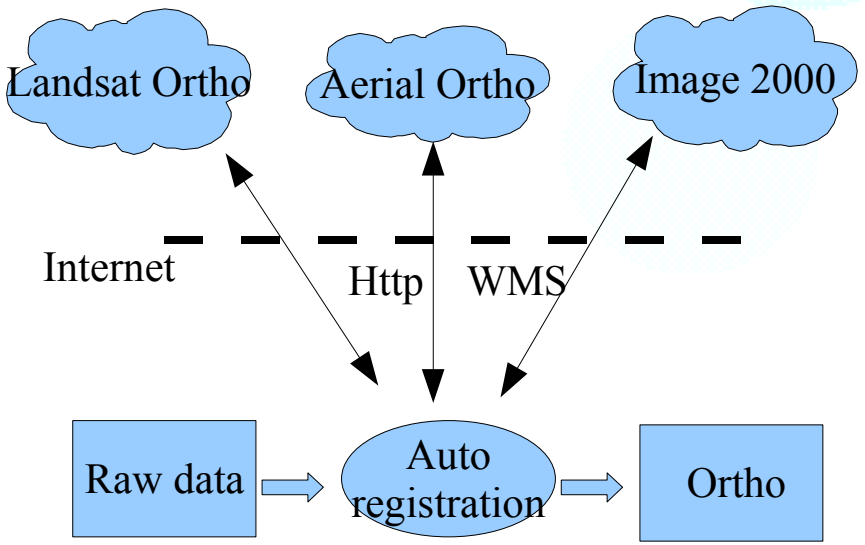
Automatic approach

- Makes direct use of already available reference data sets
- Access to WMS servers anywhere in the world
- Alternatively, locally stored data sets
- Dynamical extraction of temporary GCP chips (not preselected)



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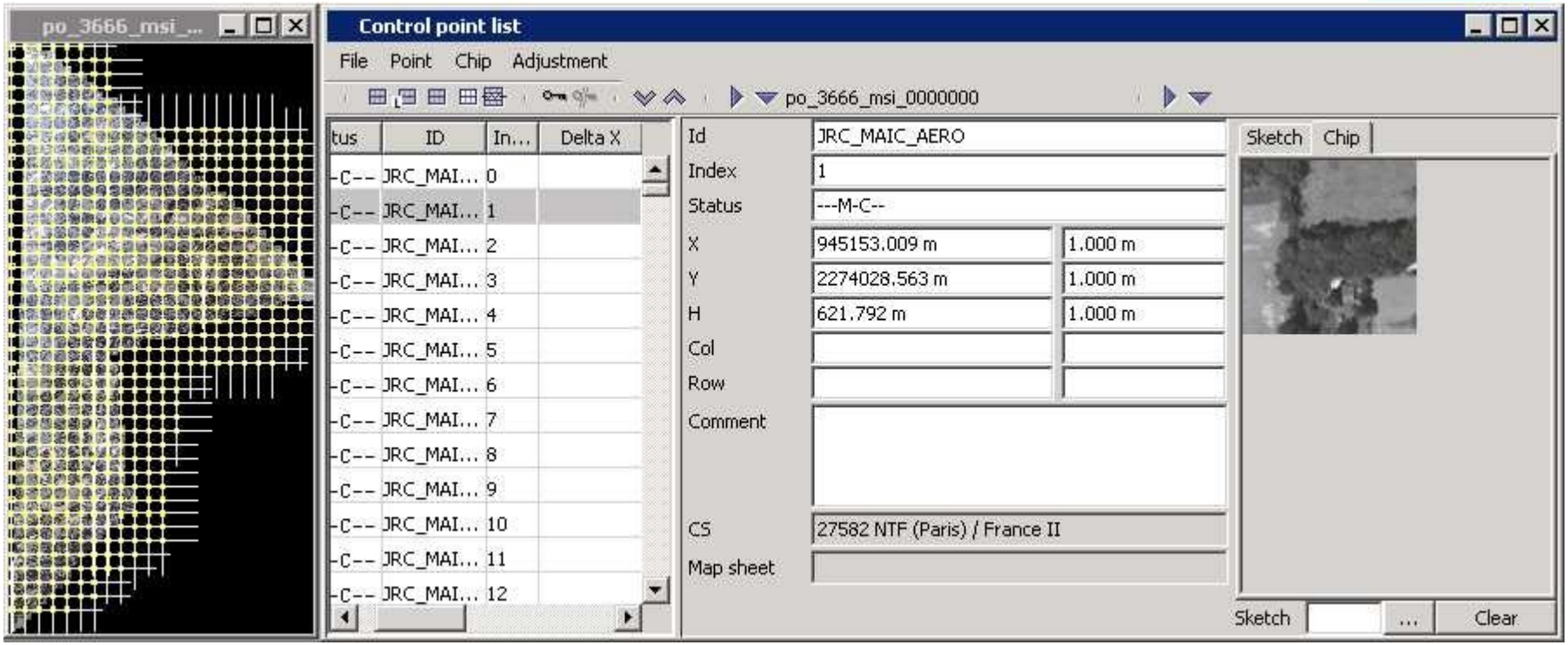
Three-stage process (1/3)

Generate dense grid of control points. Create image chps from reference imagery by WMS calls. Add elevations from global DEM (e. g. SRTM)



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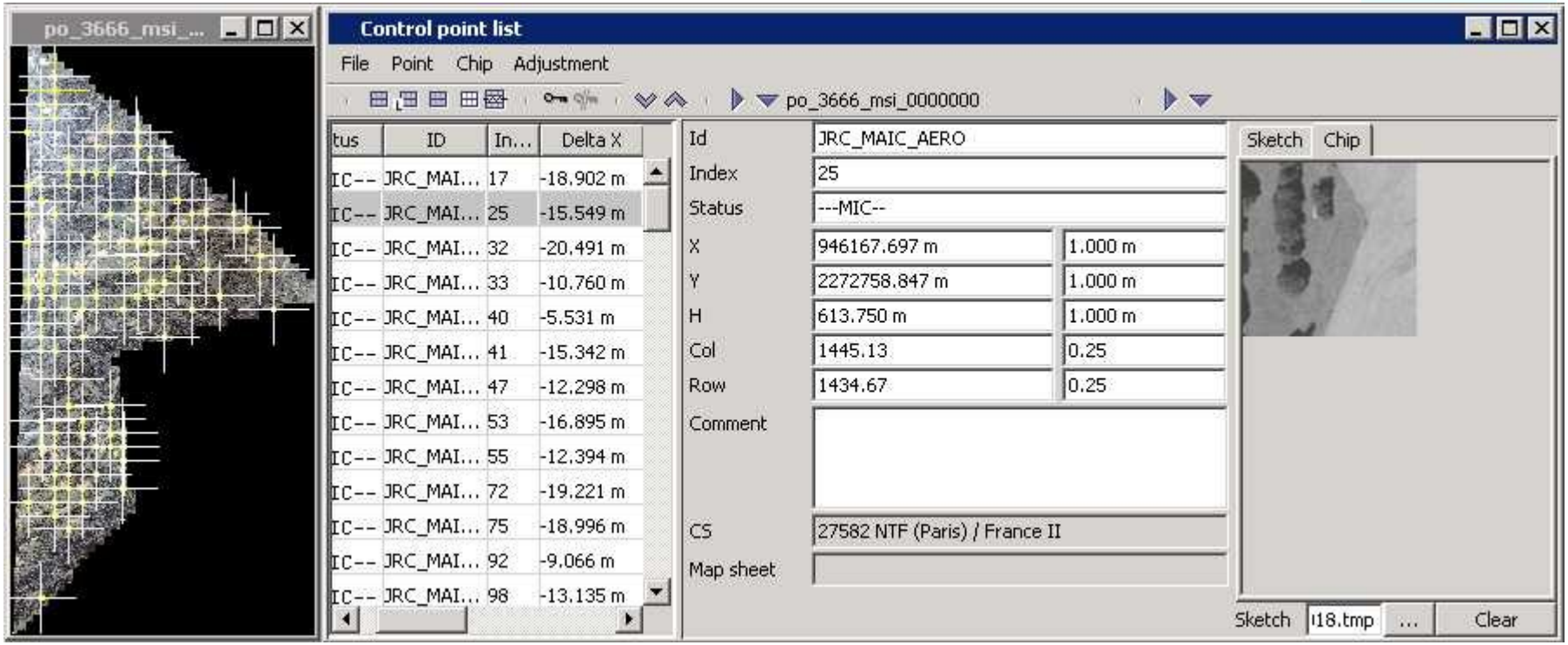
Three-stage process (2/3)

Position control points by correlation with chips. Apply threshold to correlation coefficient to eliminate initial set of bad points.



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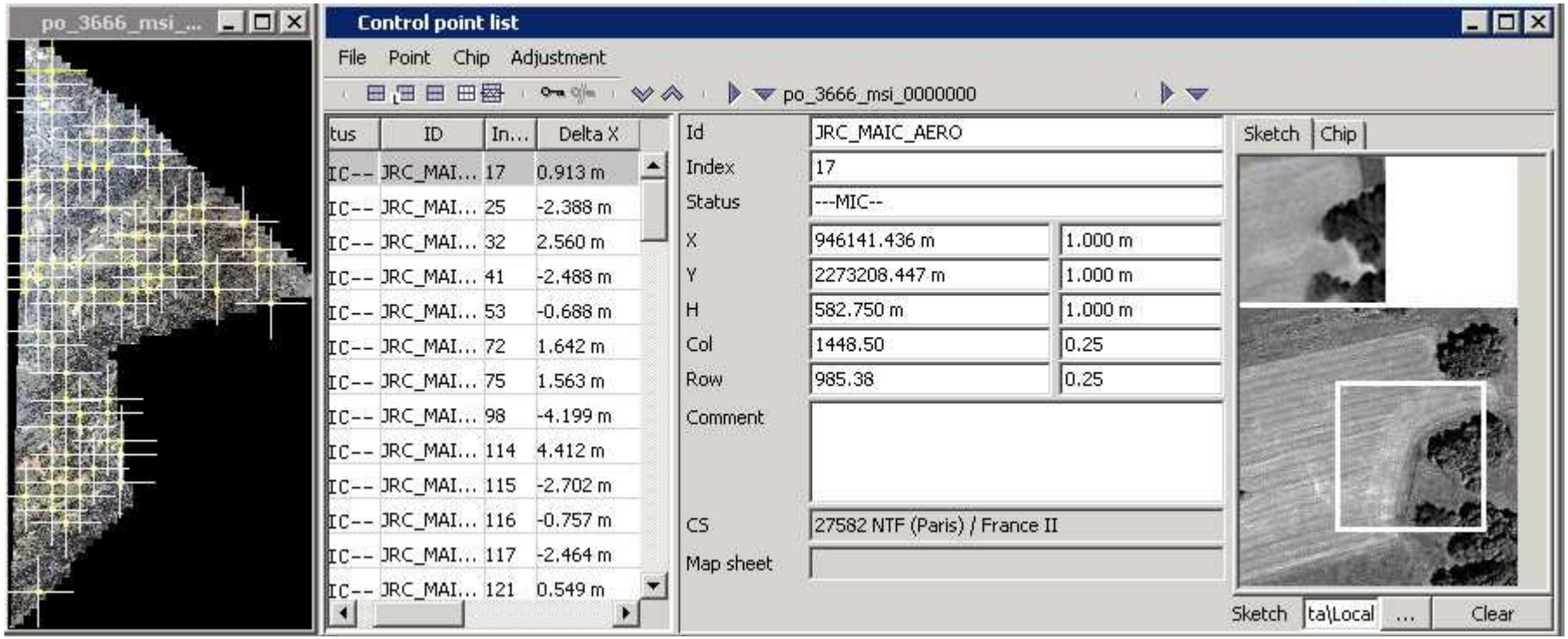
Three-stage process (3/3)

Control point adjustment with gross error detection eliminates bad ponts with false high correlation coefficient.



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Reference datasets examples

- Landsat GLCF. Global coverage (15 m) but not available as WMS
- Aerial orthophotografy. Locally available as WMS but usually no public access
- Globe DEM (1000 m grid)
- SRTM DEM (100 m grid) between +/- 60° lat.

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Example 1:
HR image registration to HR reference data sets

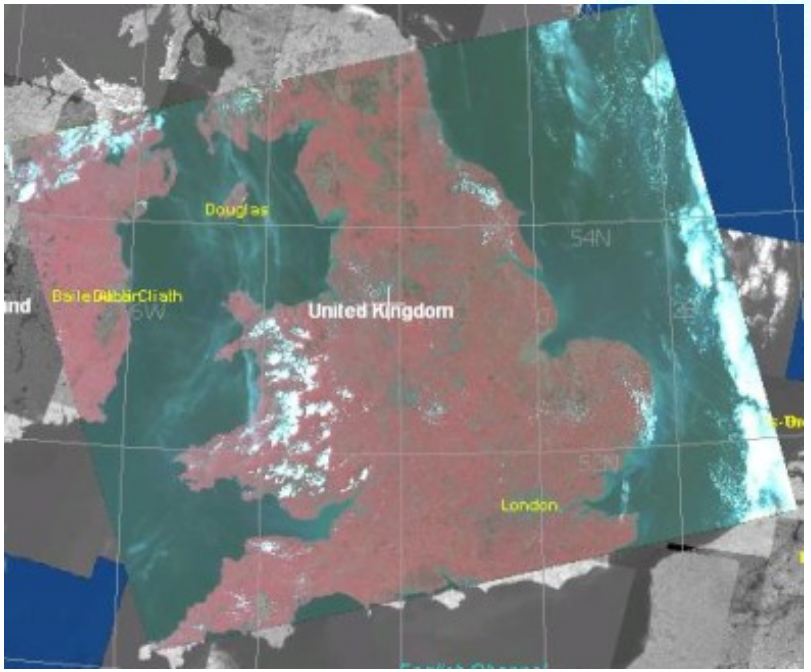
Reference:

- Landsat TM GLCF
- Globe DEM

Target:

- DMC satellites 32 m data

Used operationally by DMCii in system correction of DMC scenes. Reduces location error from 10 – 20 km to 50 – 100 m



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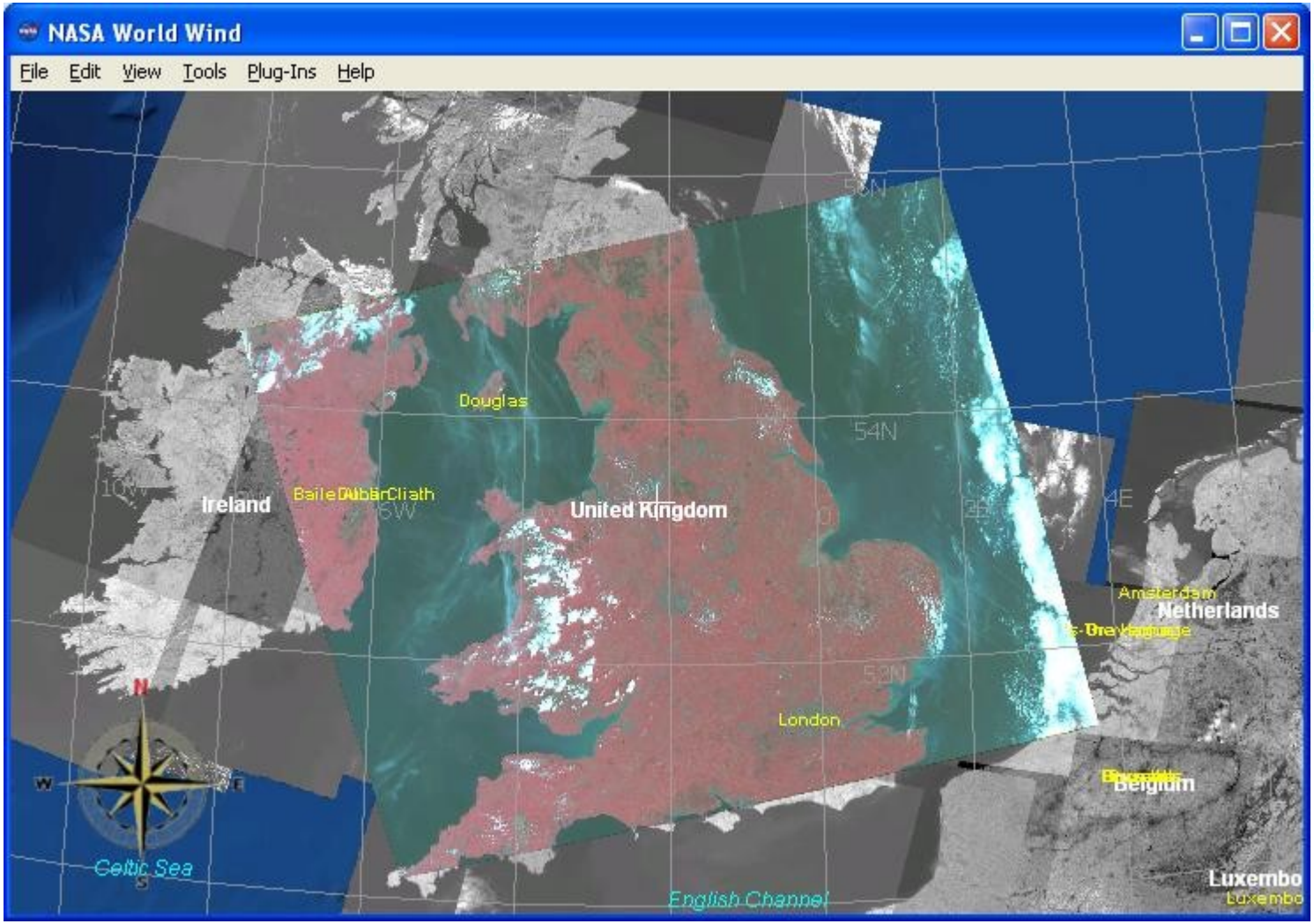

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Example 2:
VHR image registration to HR reference data sets

Reference:

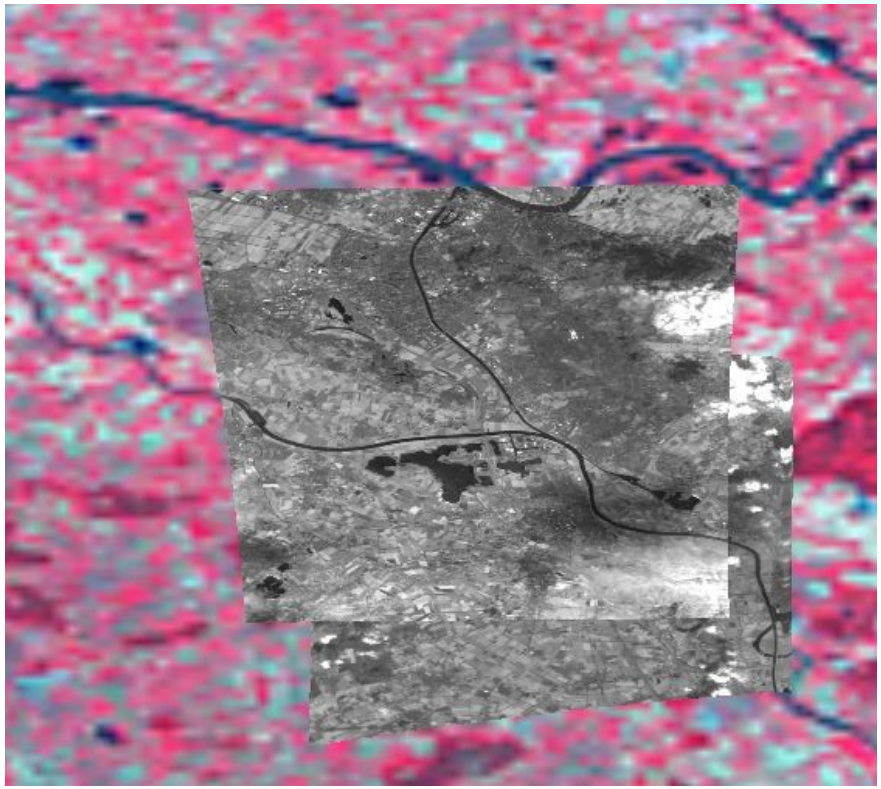
- Landsat TM GLCF
- Globe DEM

Target:

- Eros-A1 1.8 m data

Reduces location error from 1 - 3 km to 20 - 50 m

Facilitates the subsequent manual GCP measurements procedure



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JRC test dataset

- 50 scenes (Ikonos, Quickbird, Eros, Spot, Landsat)
- Aerial orthoimagery used as reference (but GLCF for Landsat)
- Local DEM when available, SRTM elsewhere

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JRC results

- Spot and Landsat results 100% successful
- VHR results primarily limited by reference data quality
- VHR results affected by bias due to long shadows in reference images
- VHR scene results 100% successful in areas with reference images of good enough qualty and without long shadows

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Example 3:
VHR image registration to VHR reference data sets

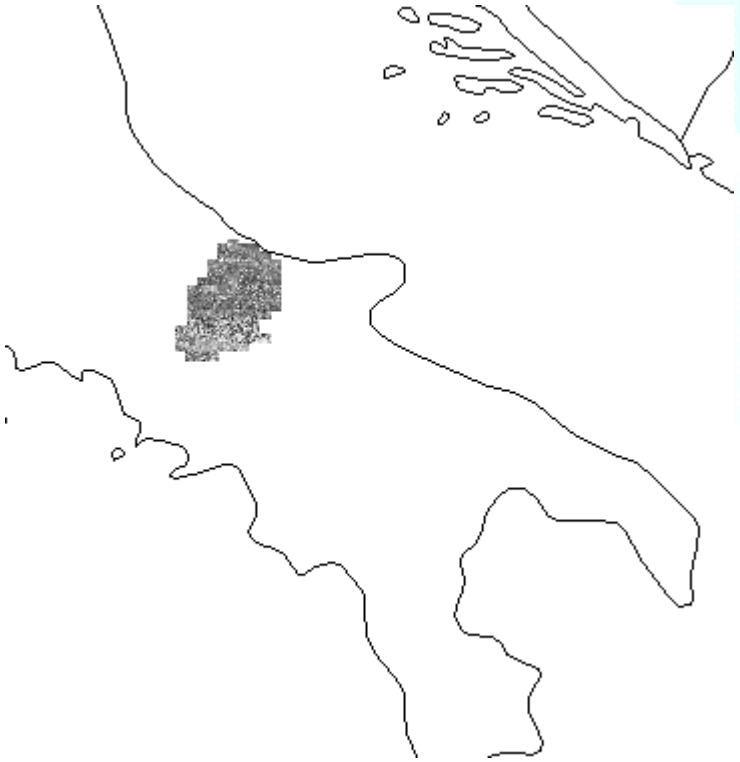
Reference:

- Aerial orthophotos 1 m
- Local DEM

Target:

- Quickbird Mul 2.4 m data

Test of automatic ortho-rectification of 14 Quickbird scenes in the Campobasso province of Italy



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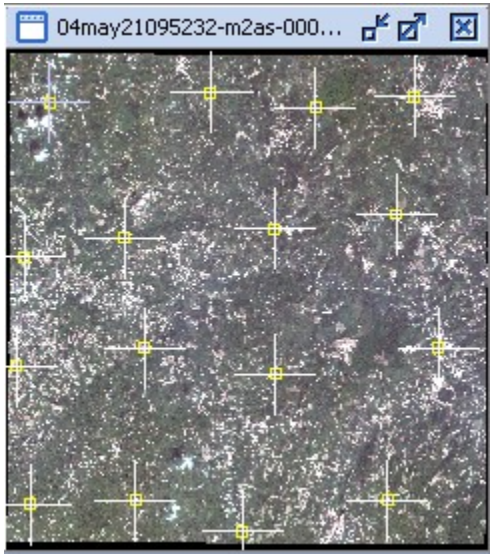
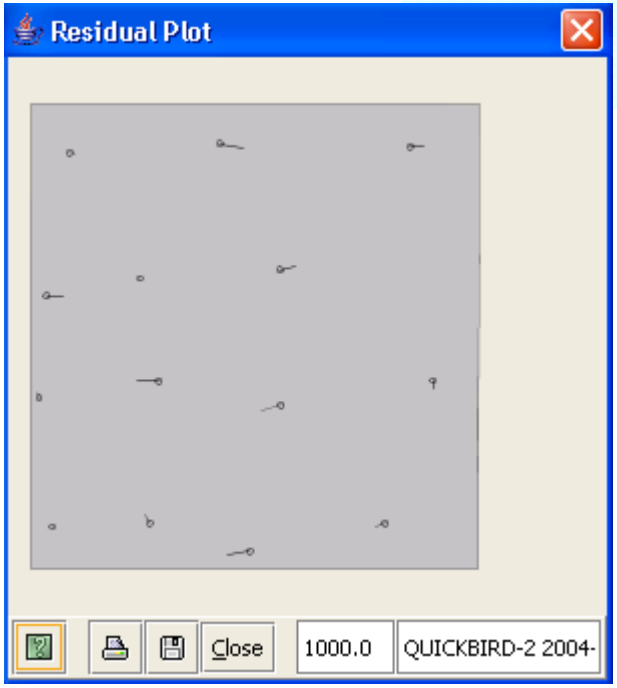
Example 3: (cont.)
Checkpoints

Orthorectification validated using 16 independent checkpoints per scene





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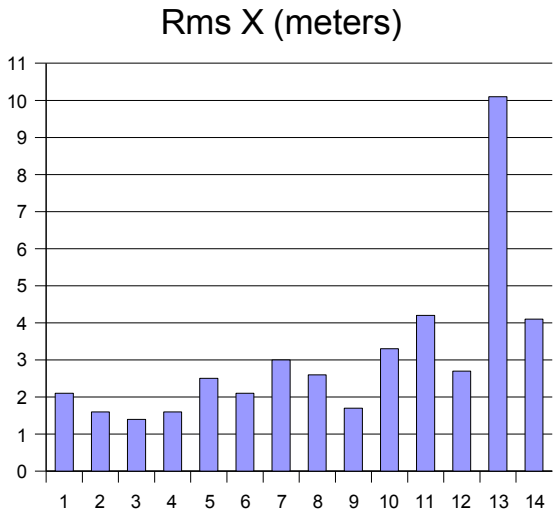
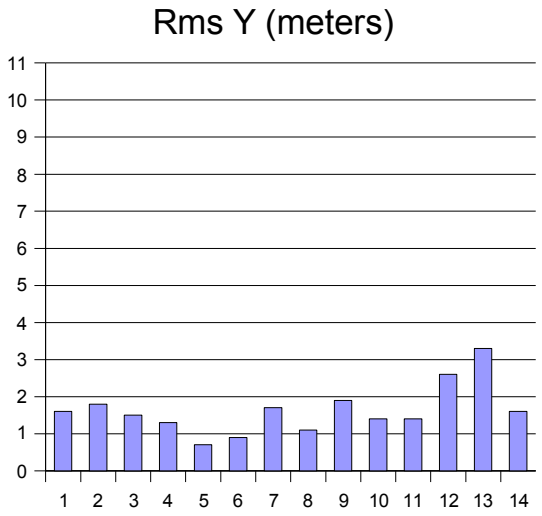
Example 3: (cont.)
Results





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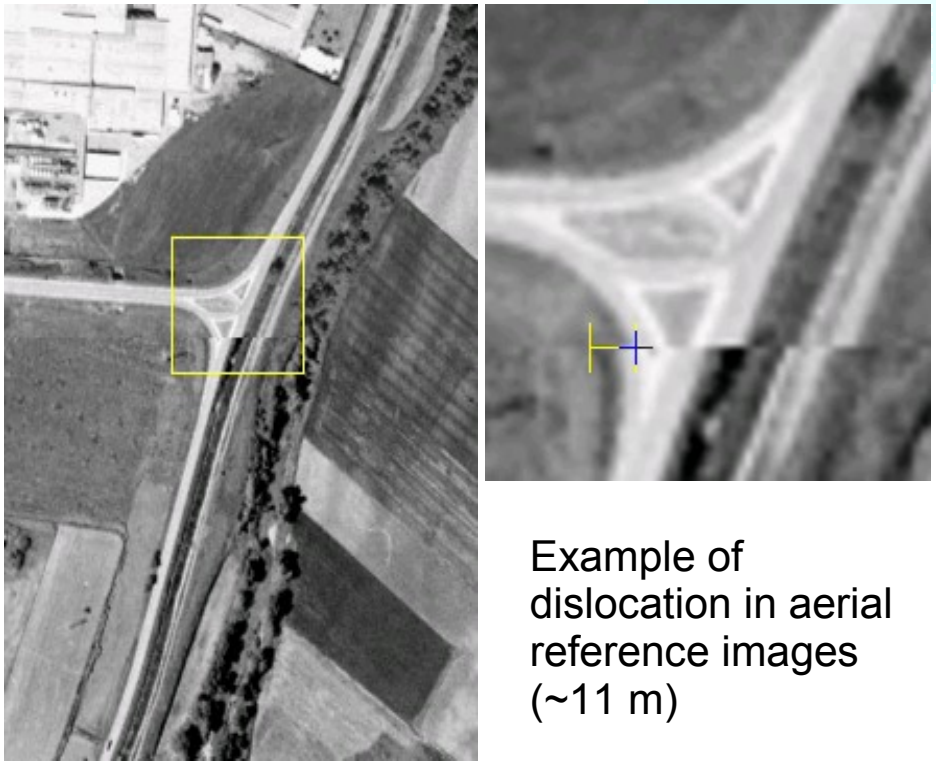
Example 3: (cont.)
Analysis

- Subpixel accuracy achieved in a majority of scenes
- An analysis of the large errors in scene 12 and 13 reveals that they are caused by errors in the reference images
- Reference image errors probably also affects the results in other images
- More accurate reference data must be used to find the true potential of the method



Example of dislocation in aerial reference images (~11 m)

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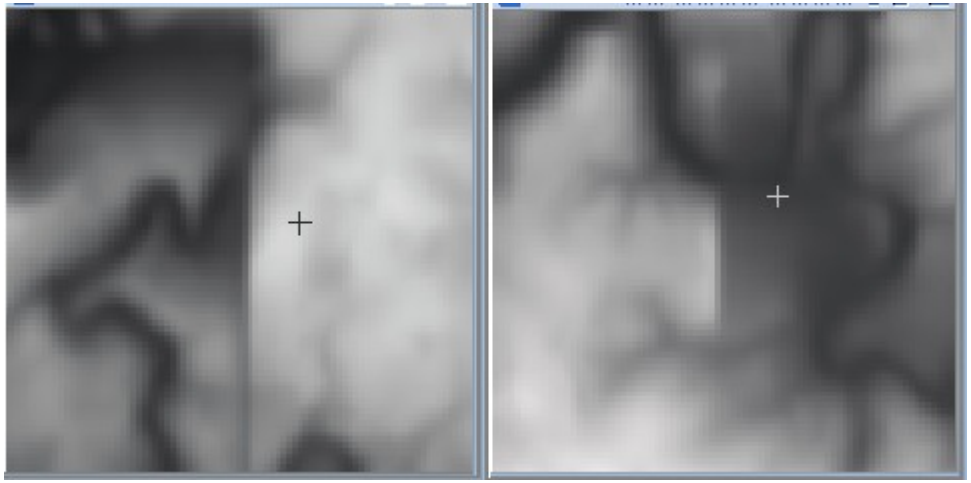
Reference data quality problems



Discontinuity in local DEM

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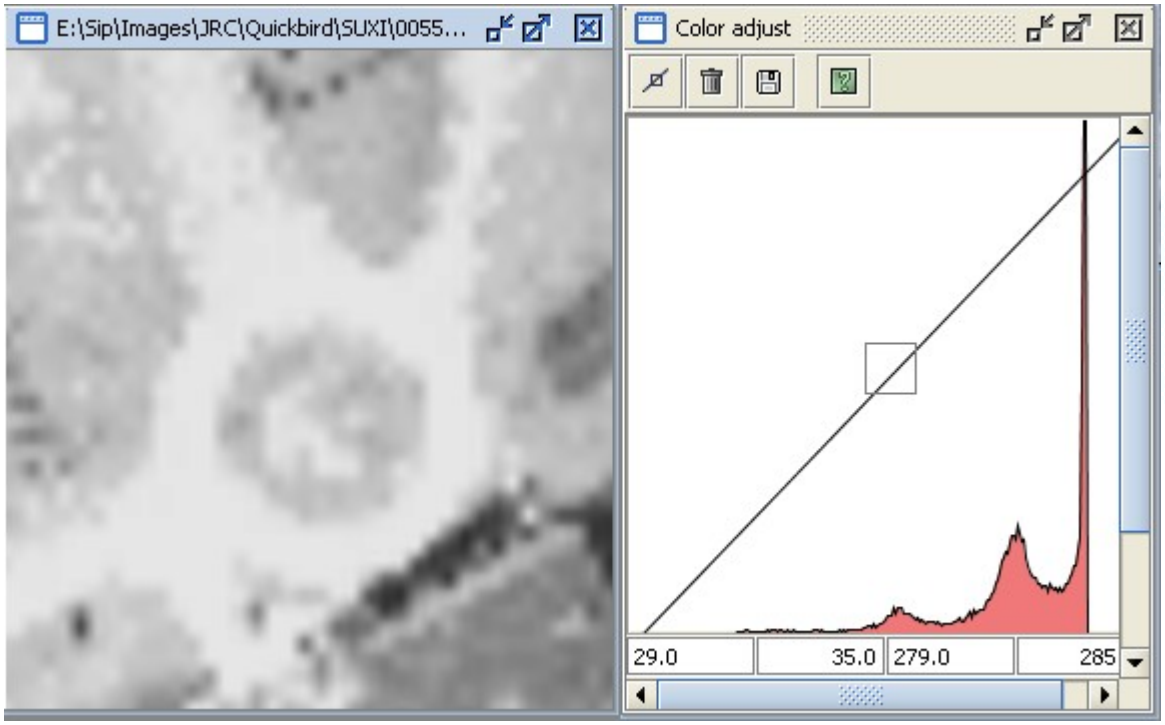
Reference data quality problems



Oversaturated orthophotos

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Reference data quality problems

Ikonos

Aerial orthophoto

Long shadows

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Conclusion

- Very high success rate for HR imagery (Spot, Landsat, DMC)
- Quality of reference data often limits the success of VHR imagery
- Long shadows due to morning or late afternoon aerial photo acquisitions is a difficult problem for VHR

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