# Influence of camera distortions on satellite image registration and change detection application

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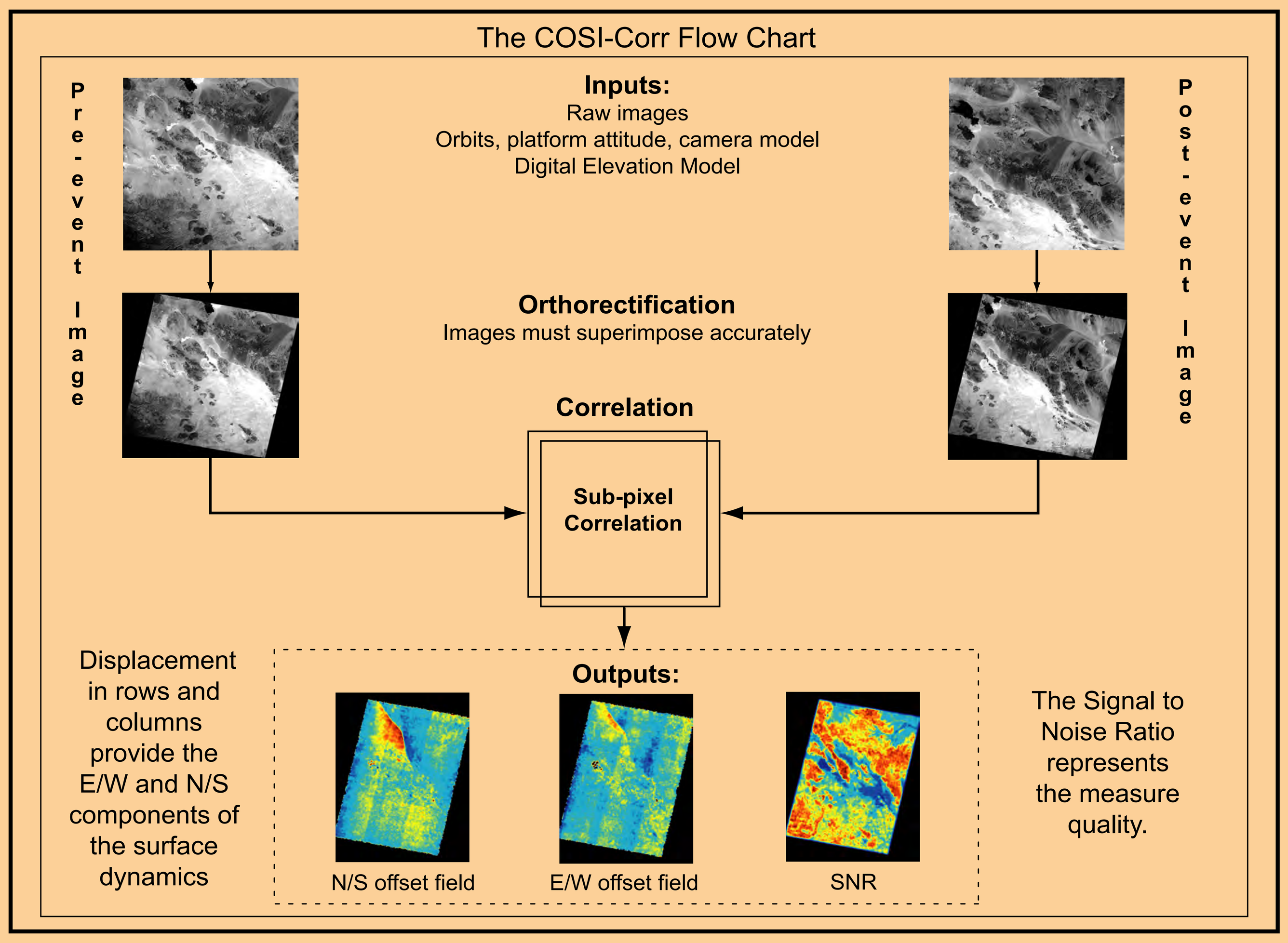
ABSTRACT: Applications such as change detection and digital elevation model extraction from optical images require a rigorous modeling of the acquisition geometry. We show that the unrecorded satellite jitter during image acquisition, and the uncertainties on the CCD arrays geometry are the current major limiting factors for applications requiring high accuracy. These artifacts are identified and quantified on several optical satellites, i.e., SPOT, ASTER, Quickbird, and HiRISE.

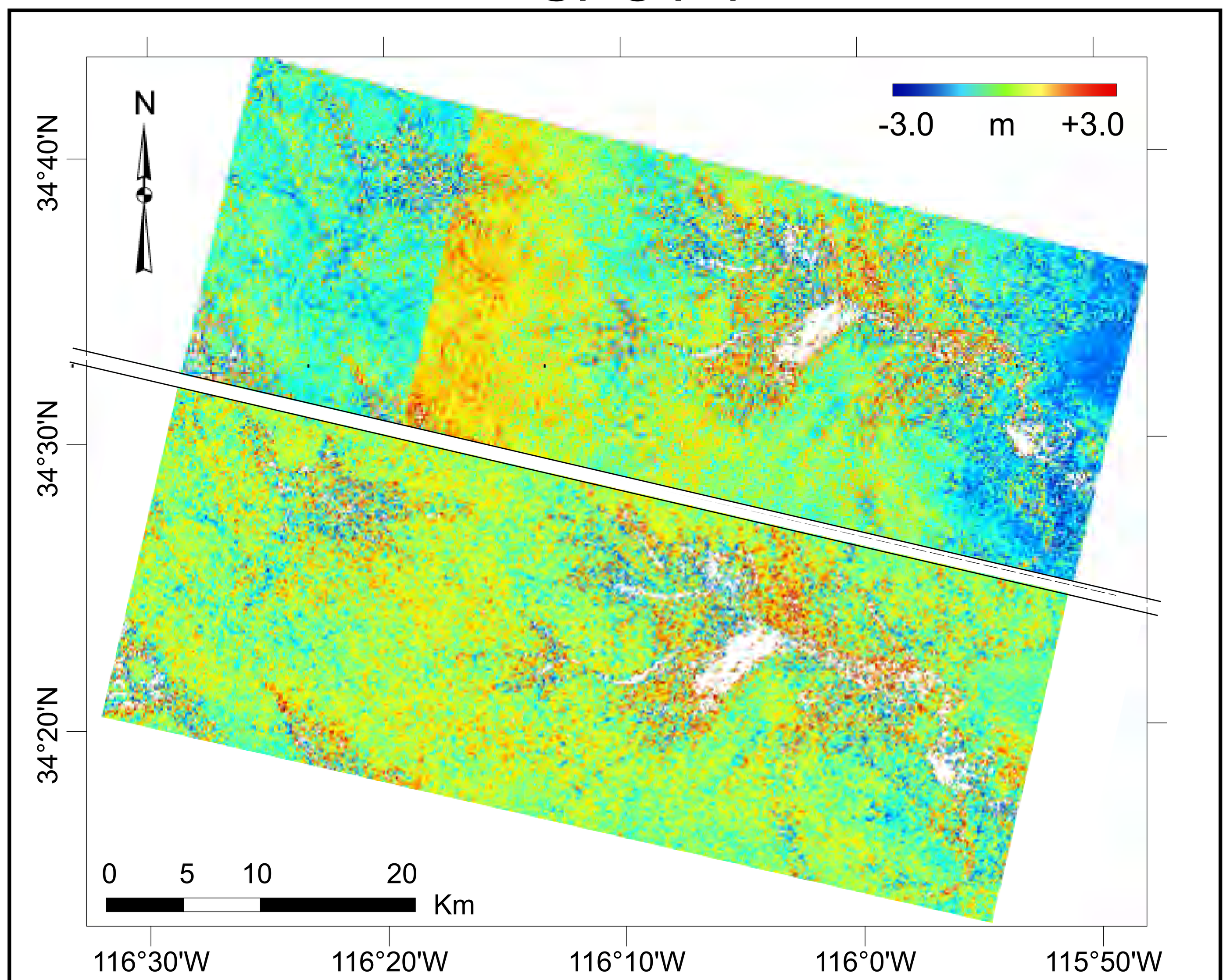
## QUESTION:
## What are the major sources of limitation for applications requiring high geometric accuracy ?

Co-Registration of Optically Sensed Images and Correlation (COSI-Corr) [1], allows for precise orthorectification, coregistration, and correlation of optical images. The software package is available at: http://www.tectonics.caltech.edu/slip_history/spot_coseis.




[1] S. Leprince, S. Barbot, F. Ayoub, and J. P. Avouac, "Automatic and precise ortho-rectification, coregistration and sub-pixel correlation of Satellite images, application to ground deformation measurements," IEEE Trans. Geosci. Remote Sens., vol. 45, pp. 1529–1558, 2007.

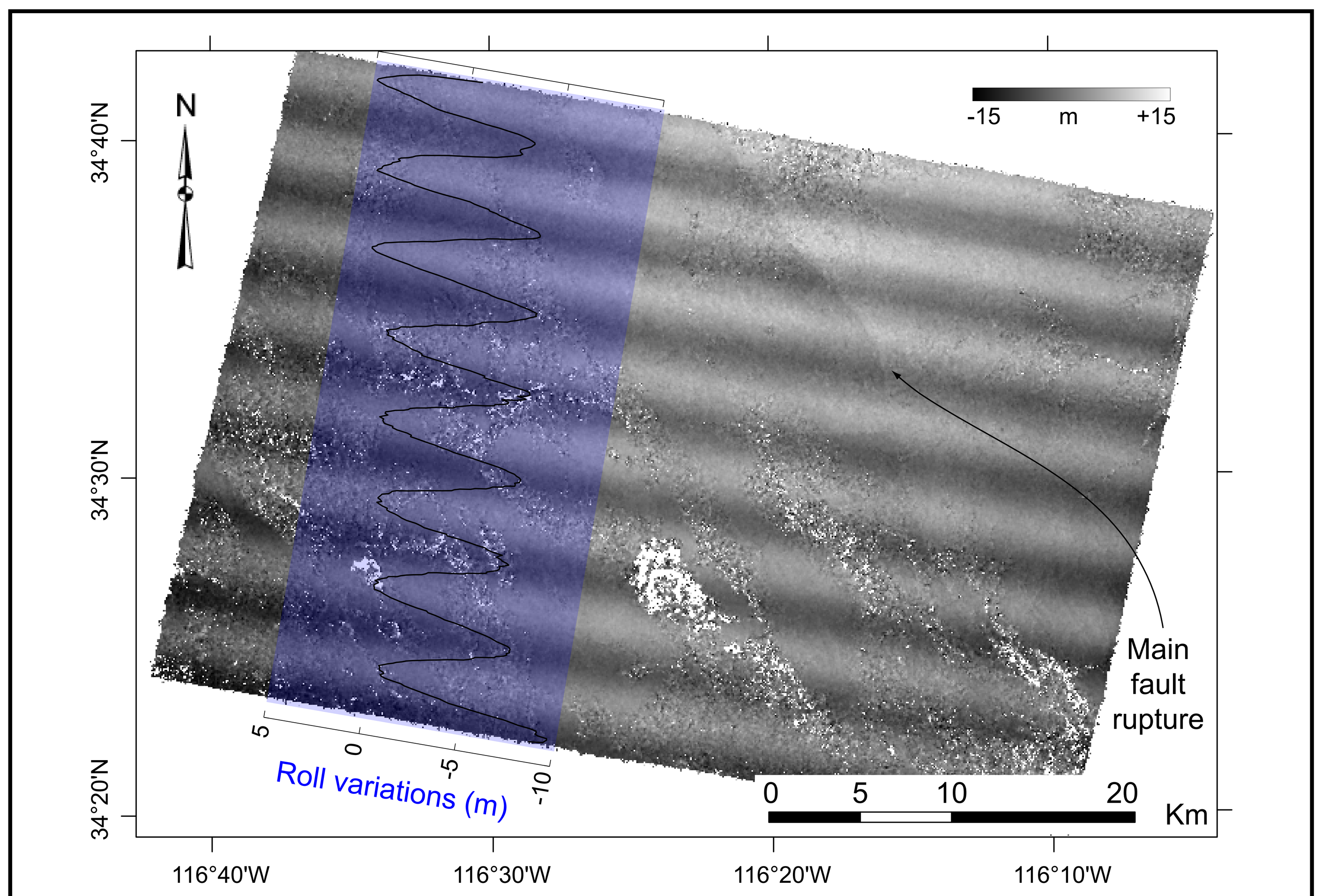
## SPOT 4




East-West component of two disparity fields measured from subpixel correlation of a reference 5-m SPOT 5 image and a 10-m SPOT 4 image near Hector Mine, California. Top: the camera geometry provided by SPOT Image Corp. was accounted for. Linear artifacts from SPOT 4 CCD misalignments are identifiable with amplitude greater than 1m. Bottom: the disparity field was generated using the same images but the SPOT 4 CCD arrays misalignments were calibrated according to [1]. Correlation analysis were performed with COSI-Corr on 32x32 pixels window, sliding with a step of 8 pixels.

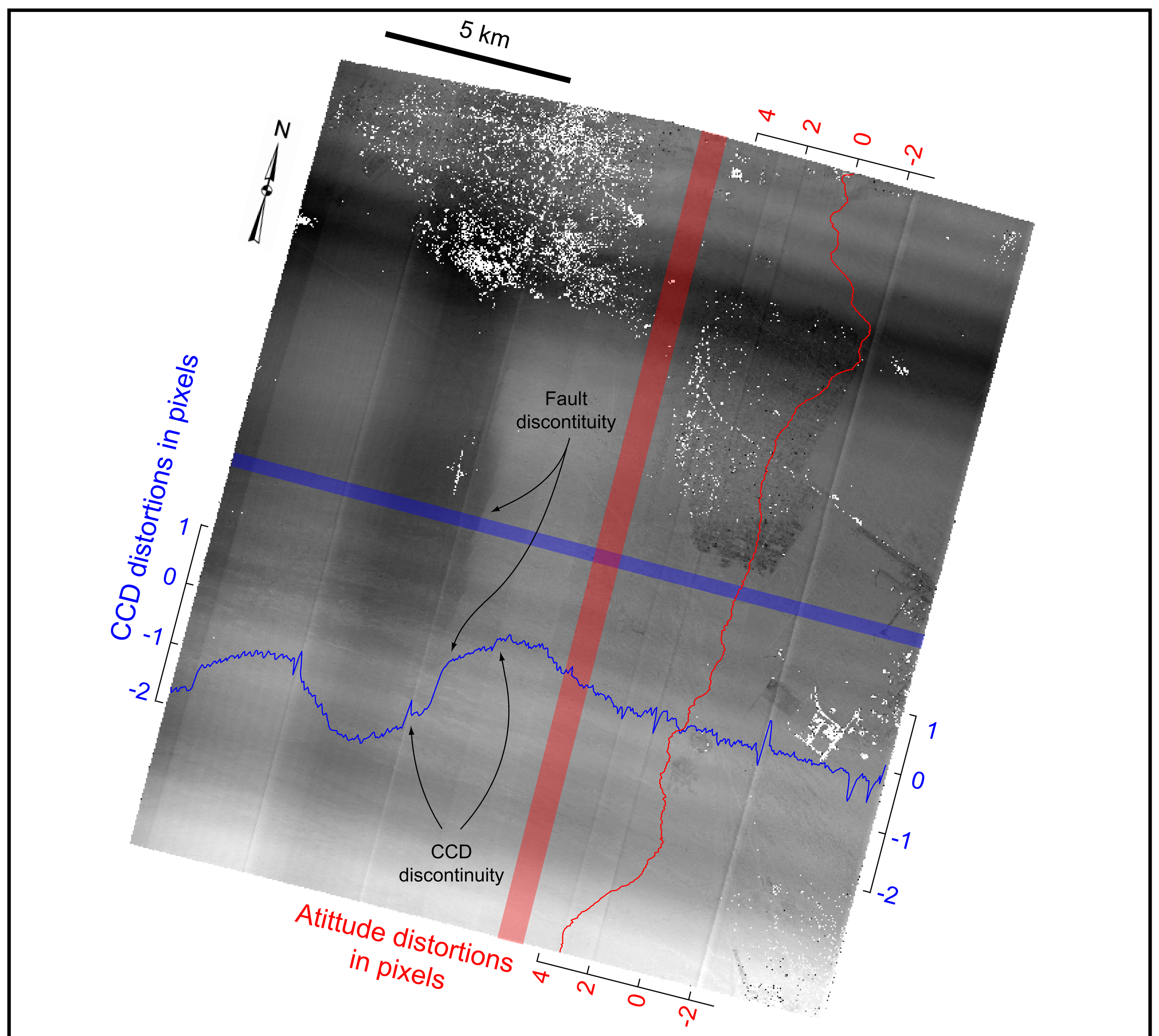
[1] S. Leprince, P. Musé, and J. P. Avouac, "In-flight ccd distortion calibration for pushbroom satellites based on subpixel correlation," 2007, submitted.

## ASTER



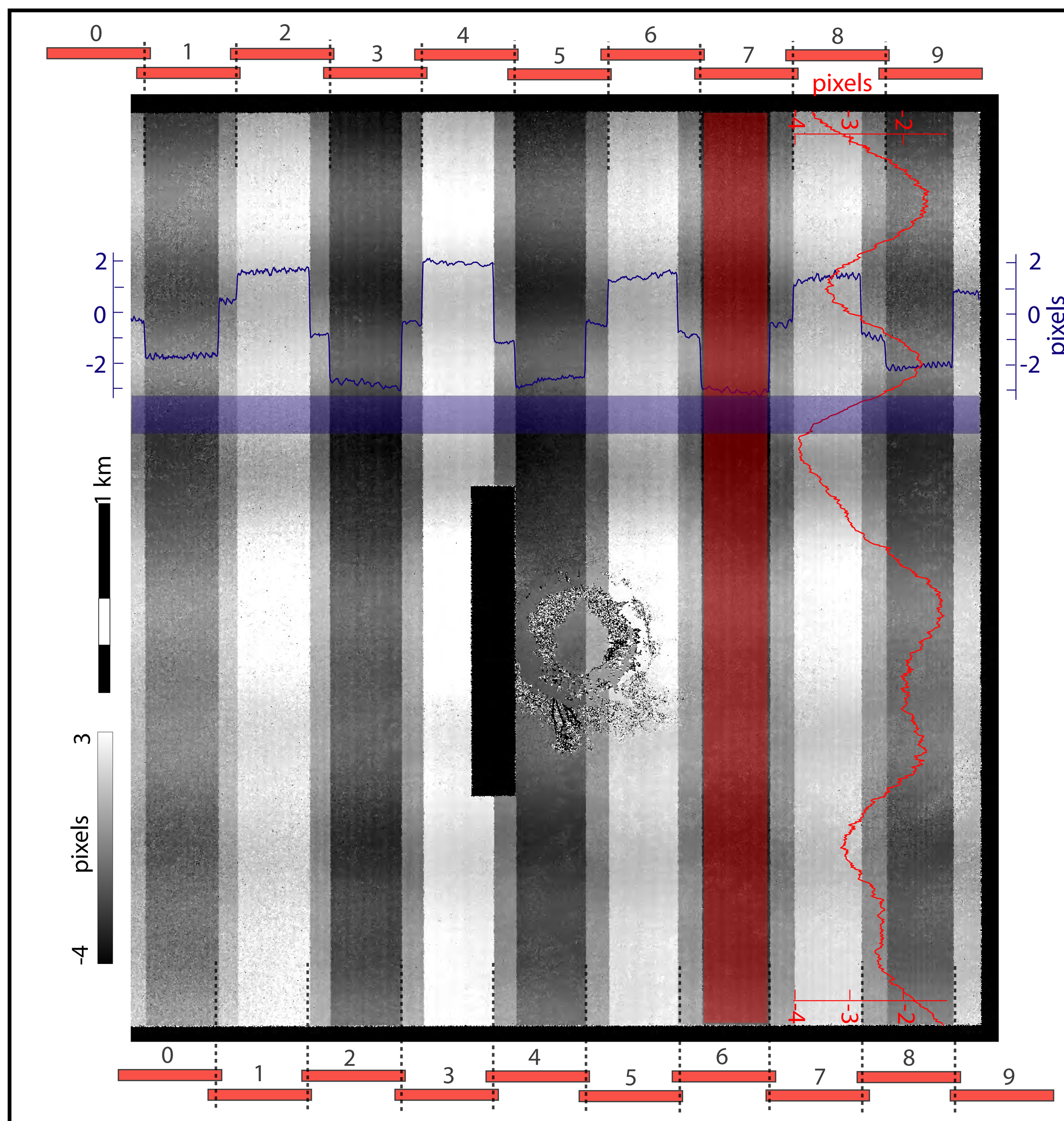

East/west component of the disparity field measured between a SPOT 4 and an ASTER images, acquired on May 10, 2000, and on August 17, 1998 over the Hector Mine area, California. Images were orthorectified on a 10 m resolution UTM projection, and subpixel correlation was performed with COSI-Corr on 32x32 pixels windows, sliding with a step of 8 pixels. The SPOT 4 image was corrected for CCD arrays misalignments as shown in the SPOT 4 figure. The goal of this study was to detect and measure the ground rupture produced during the 1999, Mw 7.1, Hector Mine earthquake. The fault rupture is identifiable but accurate measurements are difficult due to the oscillating bias induced by the unmodeled jitter of the ASTER spacecraft during the image acquisition.

## Quickbird

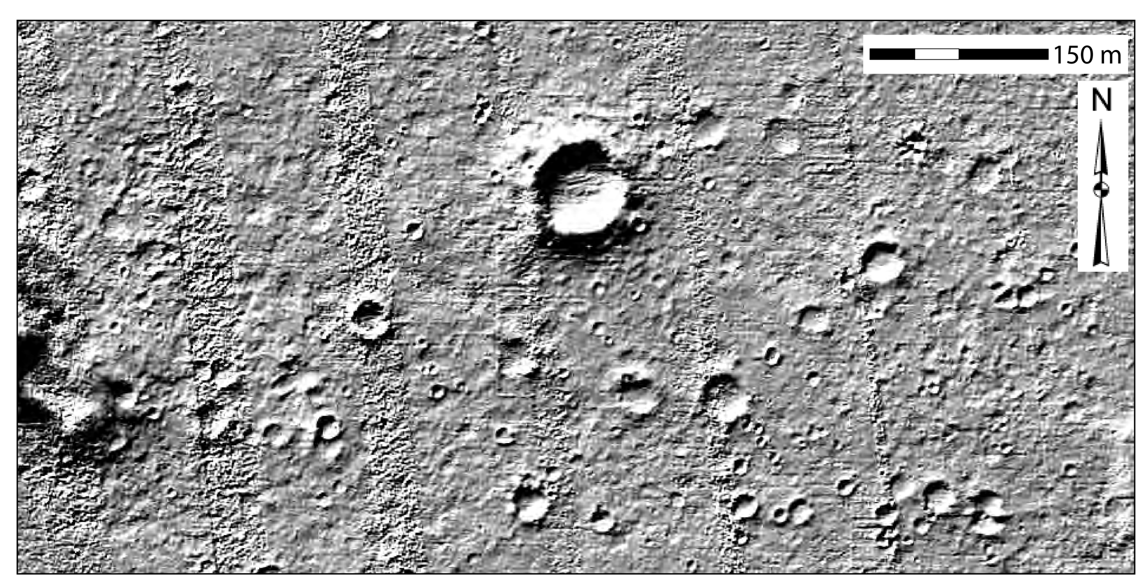



Disparity field in the direction orthogonal to the epipolar direction between two Quickbird images acquired above the city of Bam, Iran, on September 30, 2003, and on January 03, 2004. Images were resampled at a 50 cm resolution and subpixel correlation was performed on 128x128 pixels windows, sliding with a step of 64 pixels. The goal of this study was to detect and to measure the ground rupture produced during the Mw6.6 Bam earthquake of December 26, 2003. In this geometry, the fault rupture is measured to be less than 2 pixels (less than 1 m), but accurate measurements are difficult due to the bias imposed by distortions from the imaging system such as CCD interconnection discontinuity and jitter artifacts. In particular, a CCD distortion seems to exactly coincide with the coseismic signal to be measured. White areas are decorrelation areas, mostly produced by the collapse of buildings during the earthquake.

## HiRISE




Along-track component of the disparity field measured between two 25-cm HiRISE images. The images reconstruction, in the focal plane, accounted for the radiometry, camera geometry, spacecraft attitudes and ephemerides. Topography was not accounted for, but the identical viewing angles remove any stereoscopic effect. Subpixel correlation was performed with COSI-Corr on 64x64 pixels windows, sliding with a step of 16 pixels. The black stripe is due to missing data in one image, and the decorrelation area right of the black stripe is caused by large areas covered with fine material that appear featureless at the correlation window size. Strong artifacts are found in the column and line directions. Crosstrack artifacts (red profile averaged in line direction over the red box) reveal unmodeled spacecraft jitter, while along-track artifacts (blue profile averaged in column direction over the blue box) are produced by a probable combination of CCD arrays misalignment and unmodeled jitter on staggered CCD arrays. The CCD arrays' relative position of the two images are sketched above and below the disparity field.




Shaded DEM generated from HiRISE imagery near Columbia Hills with ISIS3 and BAE SOCET-SET softwares. Residual CCD misalignments generate artifacts in the DEM with an amplitude of around 1 m.

## CONCLUSION:
## Unrecorded satellite jitter and uncertainties on the CCD arrays geometry appear to be the major limiting factors for applications requiring high accuracy