IMPACT OF THE SPATIAL RESOLUTION ON SAR CHANGE DETECTION

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ABSTRACT

This paper presents an analysis of multi-pass interferometric acquisitions at very high resolution acquired over Salon de Provence area, south of France. These acquisitions were obtained from the ONERA/RAMSES SAR sensor at X band. The coherence information is analyzed for change detection purpose and the impact of spatial resolution on scene understanding and change detection processing are studied.
The ONERA RAMSES [1] system is a flexible multi-frequency SAR system, developed mainly as a test bench for new SAR modes, providing dedicated data for various applications including TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160 platform operated by the French Flight Test Centre CEV (Centre d'Essais en Vol).

***Index Terms*—** Very High Resolution, coherence, change detection.

1. INTRODUCTION

With the increasing development of SAR satellites, especially at X band, more and more sophisticated data products have been made available such as high resolution and interferometric images with applications such as accurate DEM generation and change detection.
This paper is focused on the impact study of the spatial resolution on coherent change detection. First, a qualitative analysis is presented with respect to scene understanding and then, results derived from the application of a change detection algorithm.
The corresponding radar data have been collected with RAMSES, the ONERA airborne multispectral SAR sensor. Starting from high quality SAR images, downgraded resolutions have been computed to allow parametric analysis.

2. ACQUISITION CAMPAIGN

The acquisition campaign took place during summer 2006 [2] [3]. Various kinds of background have been imaged: industrial, urban, vegetated and hilly areas. One of the major goals of the campaign was to study temporal decorrelation at X band, and changes due to human activities showing up at different resolutions. Most of the data were acquired with a sub-metric range resolution and computed to be representative with present space borne SAR systems.
During this campaign, very high resolution data, up to decimetric slant range resolution, were also collected. Two different waveforms were used. The first one was a 5 step synthetic chirp waveform in single polarization mode. The effective bandwidth is 1.2GHz. The second was a 3 step frequency synthetic chirp waveform in full polarimetric mode. The effective bandwidth is 900MHz. The incidence angle is 50°. The delay between these two acquisitions is two days. The images were computed with a pixel spacing of 0.1x0.1m at decimetric resolution, along slant range and azimuth axis. Images size is: 1000x6700m in slant SAR geometry corresponding to 1550x6700m on ground.

The area under study is located in the neighborhood of Salon de Provence. This area was selected close to ONERA premises, thus offering the opportunity to collect accurate ground truth, in addition to providing appropriate natural and man-made background with evolutive construction work.

3. IMPACT OF THE SPATIAL RESOLUTION

Scene understanding

The color composite images, Figure 1, Figure 4 and Figure 7, allow a quick analysis of observed changes. The colored images are derived from both magnitude SAR images (red and the green channels) and the coherence image (blue channel). Then the most coherent parts within the images appear in blue, or white for strong scatterers, and the non coherent parts appear in yellow or red/green for strong scatterers that have changed between acquisitions.

Spatial resolution has a strong impact regarding scene understanding. Metric resolution (Figure 1) doesn’t allow recognition of details to a scale smaller than a typical house, such as foundations (Figure 3). Areas that have changed are globally highlighted but one lacks interpretation capability.
A metric resolution could be useful to determine which parts of the image have changed but is not sufficient to describe them.

Sub-metric resolution (Figure 4) allows to detect and analyze several changes. Thin details appear even if it is difficult to interpret them, as shown on Figure 6, of the Houses foundations are for example detectable.
Sub-metric resolution allows a good location of changes and gives an idea about the causes of changes. If one has previous knowledge of the scene then half metric resolution could be sufficient for monitoring the changes.
Decimetric resolution is suitable to analyze and understand small changes due to human activities as shown Figure 7**.** House foundations are then clearly identifiable (Figure 8). Changes in these foundations between flights appear in red (right image) and other ones which did not evolve between flights appear in blue (on left image).

Decimetric resolution also allows very accurate location of change detection on color composite image, thus need for extraneous sources of information for scene understanding is no longer a must.

Change detection

The change detection algorithm developed is a coherent algorithm based on statistics applied to the SAR magnitude images filtered by the coherence level. A minimum change size is considered to filter the results for false alarms reduction. The temporal decorrelation due to vegetation is filtered by the statistics on the SAR magnitude images. Windowing is applied and the window size is adapted to the spatial resolution to analyze the impact of this resolution on change detection. So the window size is constant in pixels but not in meters. Results are overlapped on the SAR images and appear in red.
Results of change detection for metric and sub-metric resolutions are presented on Figure 2 and Figure 5 respectively. The color composite images and the change detection results are closed together except for areas in yellow that mostly represent vegetation decorrelation (filtered by the change detection algorithm).
The house foundations that have evolved between flights, Figure 3 and Figure 6, are detected at both resolutions although the green part corresponding to smallest foundations (Figure 3, orange square) is not detected on the metric resolution image but is detected on the sub-metric one (Figure 6). The change detection algorithm is sensitive to parameter tuning and windowing size for objects with a size close to the resolution.

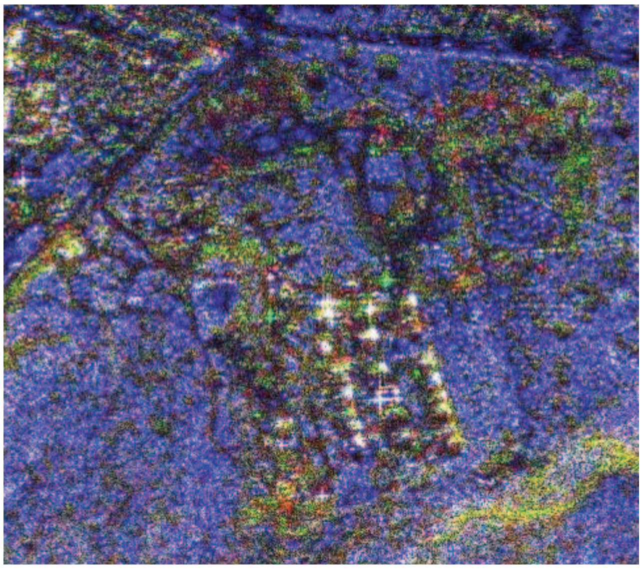

Figure 1 : color composite of metric resolution SAR image: red is the SAR magnitude image of the first acquisition, green is the SAR magnitude image of the second acquisition and blue the coherence magnitude.

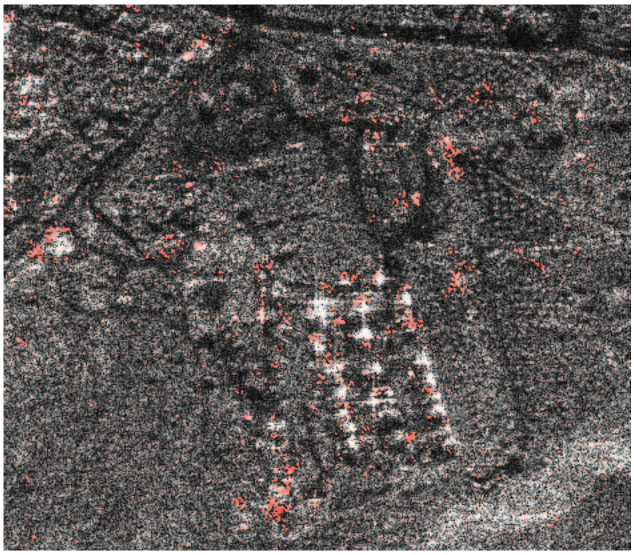

Figure 2 : change detection result, the red color localize the changes for the metric resolution image.

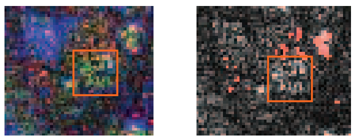

Figure 3: zoom (of Figure 1 and Figure 2) of house foundations.

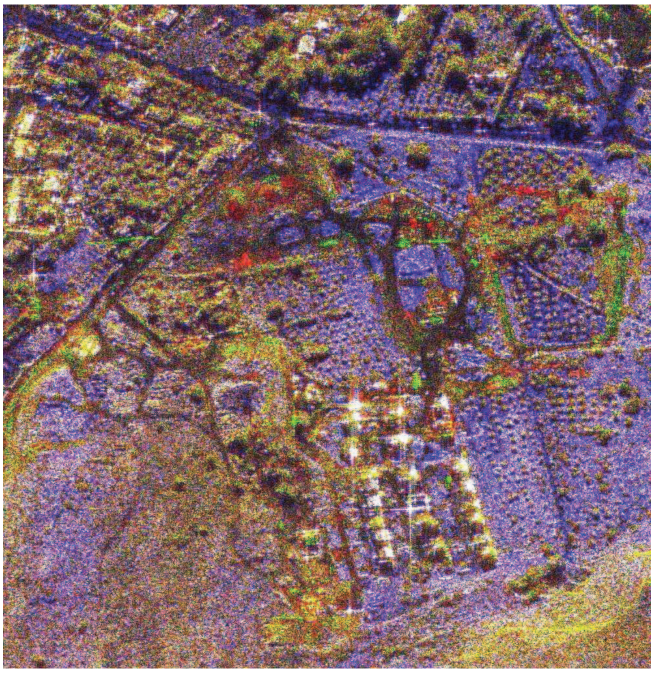

Figure 4 : color composite of sub-metric resolution SAR image: red is the SAR magnitude image of the first acquisition, green is the SAR magnitude image of the second acquisition and blue the coherence magnitude.

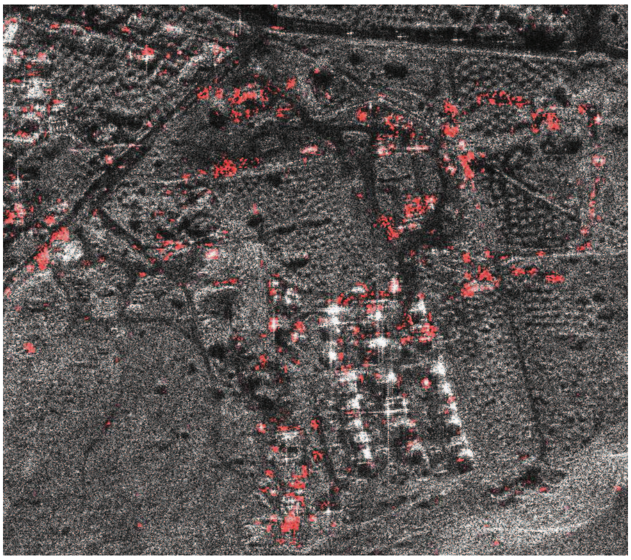

Figure 5 : coherent change detection of the sub-metric resolution SAR images.

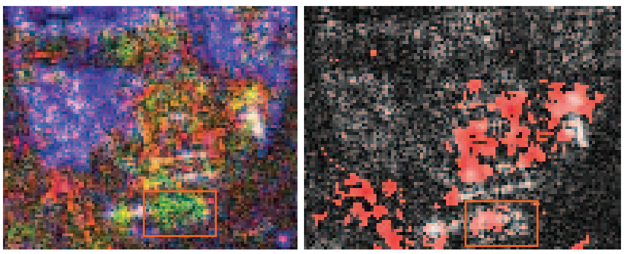

Figure 6: zoom (of Figure 4 on the left and of the Figure 5 on the right) of the foundations.

Figure 7: color composite of decimetric resolution SAR image: red is the SAR magnitude image of the first acquisition, green is the SAR magnitude image of the second acquisition and blue the coherence magnitude

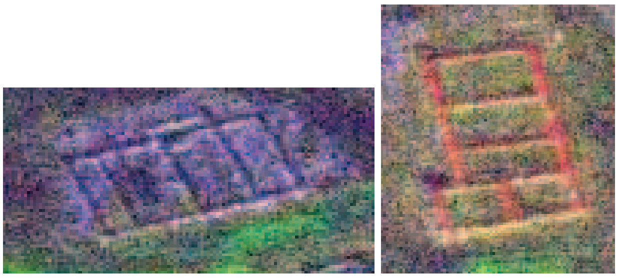

Figure 8: zoom on the housing estate foundations: left (from the white square) no change is detected (blue color), right (from the red square) these foundations were dug between the acquisitions.

4. CONCLUSION

The multi-pass interferometric products provide interesting information as coherence magnitude that gives information about changes due to human activities which could be easily pointed out. Spatial resolution is an important parameter for scene understanding and change analysis. Metric resolution is not sufficient for interpreting changes like foundation digging. Previous knowledge or extraneous source of information is necessary. Sub-metric resolution is sufficient to analyze and monitor changes such as building construction.
Therefore such metric resolution provided by space borne SAR systems may be not sufficient to analyze changes: detection and monitoring of human activity is made possible but correct interpretation is often not possible. This is in contrast to advanced airborne SAR systems with spatial resolutions up to ten centimeters, then allowing change monitoring and understanding without additional data.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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