

# CO<sub>2</sub> Storage: Monitoring of Related Surface Movements from Space - Potential for Central European Land Cover Conditions?

Lutz Petrat<sup>1</sup>, Jan Anderssohn<sup>2</sup>, Michael Riedmann<sup>3</sup> (Infoterra GmbH, Germany)

## 1. Background

EU Directive on Carbon Capture and Storage:

- Complex monitoring plan for CO<sub>2</sub> storage sites required - covering operation and at least 20 years after abandonment.
- Monitoring methods shall be based on best practice available for detecting the presence, location and migration paths of CO<sub>2</sub> in the subsurface and at surface.
- Technology should also provide a wide areal spread in order to capture information of the complete storage complex and beyond.

In this context, the strong potential of satellite based radarinterferometric monitoring of surface movements related to underground CO<sub>2</sub> injection was demonstrated for the BP/Statoil CO<sub>2</sub> injection project at In Salah in Algeria. In Salah offers perfect conditions for radarinterferometric techniques: No or very sparse vegetation results in strong coherence and high density of persistent scatterer interferometric (PSI) points (Figure 1).

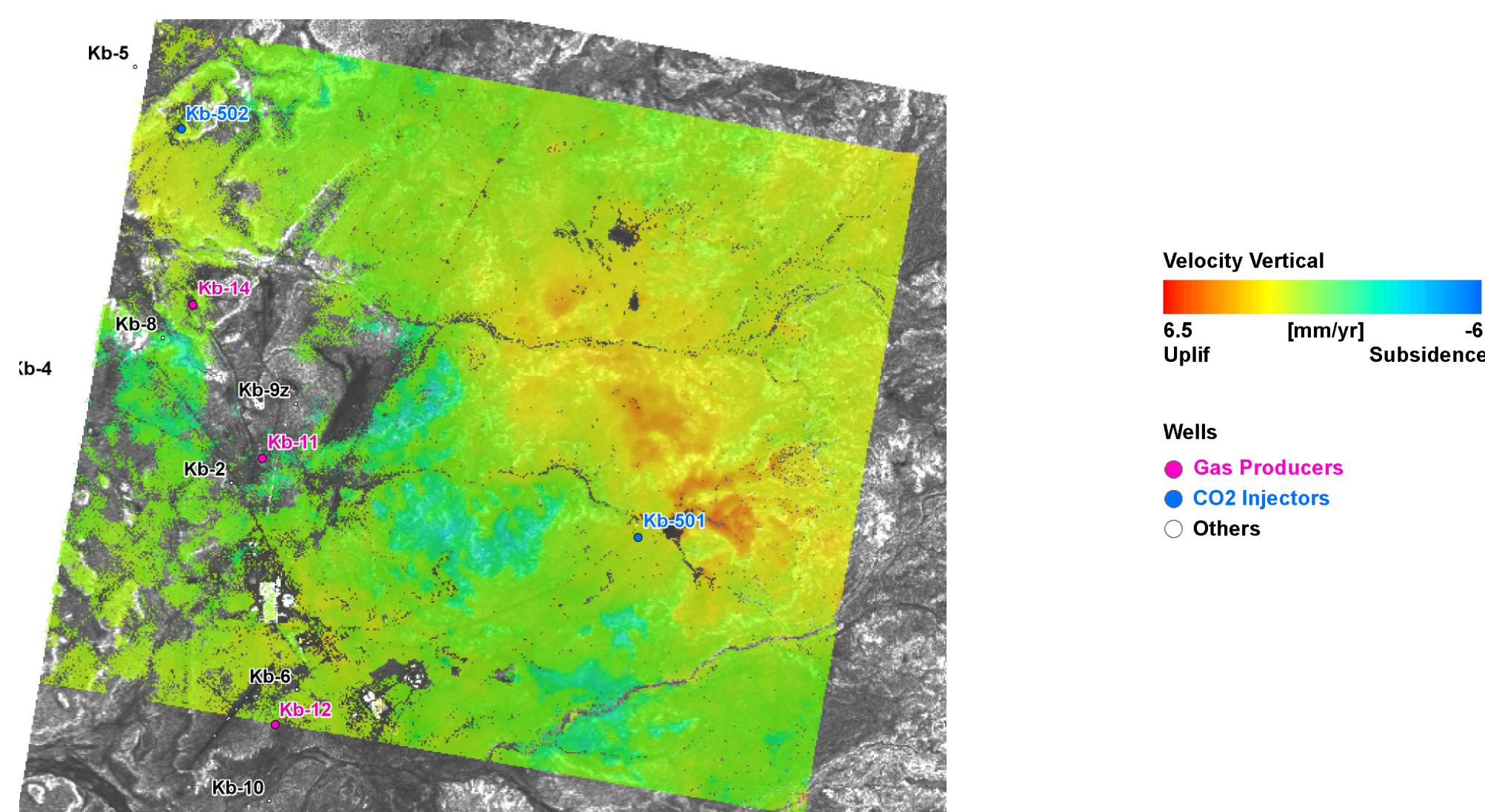


Figure 1: In Salah Gas Field (Algeria) and CO<sub>2</sub> Injection - Surface displacements resulting from PSI processing of 35 TerraSAR-X Datasets between 15/03/2008 und 29/05/2009

Future CO<sub>2</sub> storage sites in Central Europe are very likely located in areas with stronger vegetated, forest or agricultural land cover: Decorrelation problems through vegetation growth/movement and agricultural activity result in low long term coherence and lower density of PSI points.

→ Need for a demonstration of the methods' suitability under Central Europe surface conditions to further establish this very promising technology.

## 2. Objective

Evaluation, whether the method can contribute to a monitoring program for future onshore CO<sub>2</sub> storage sites in Central Europe. Figure 2 clearly shows the difference in PSI point density in comparison between In Salah CO<sub>2</sub> injection site and Central European land cover conditions.

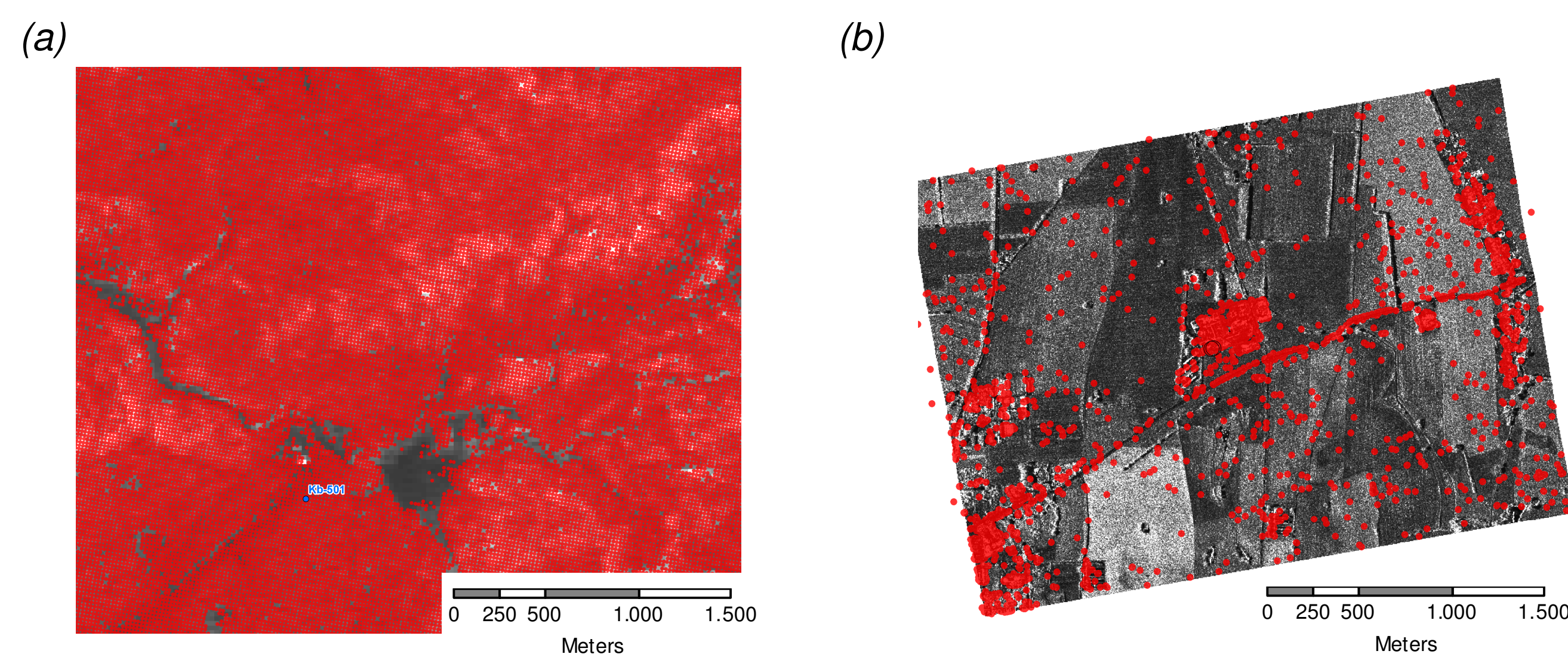


Figure 2: Comparison of PSI point density (red dots) based on TerraSAR-X StripMap data (same scale) – (a) In Salah, Algeria, (b) Ketzin CO<sub>2</sub> Pilot Project, Germany

## 3. Area of Interest

German CO<sub>2</sub> pilot storage site Ketzin near Berlin, Germany:

- Abandoned gas storage site
- Land cover typical for Central European rural areas: Dominated by agricultural and forest areas.
- Depth/thickness of formation relevant for CO<sub>2</sub> injection: 600 m to 700 m / approx. 80 m
- Injection Start: Summer 2008
- Injection Duration: 2 years
- Maximum amount of CO<sub>2</sub> to be injected: 60.000 tons

## 4. Approach

Use of ENVISAT ASAR (C-Band, spatial resolution approx. 25 m) and TerraSAR-X StripMap data (X- Band, spatial resolution approx. 4 m) for a PSI processing approach.

## 5. Results

A comparison of results from using different wavelengths and ground resolution is visualized in Figure 3:

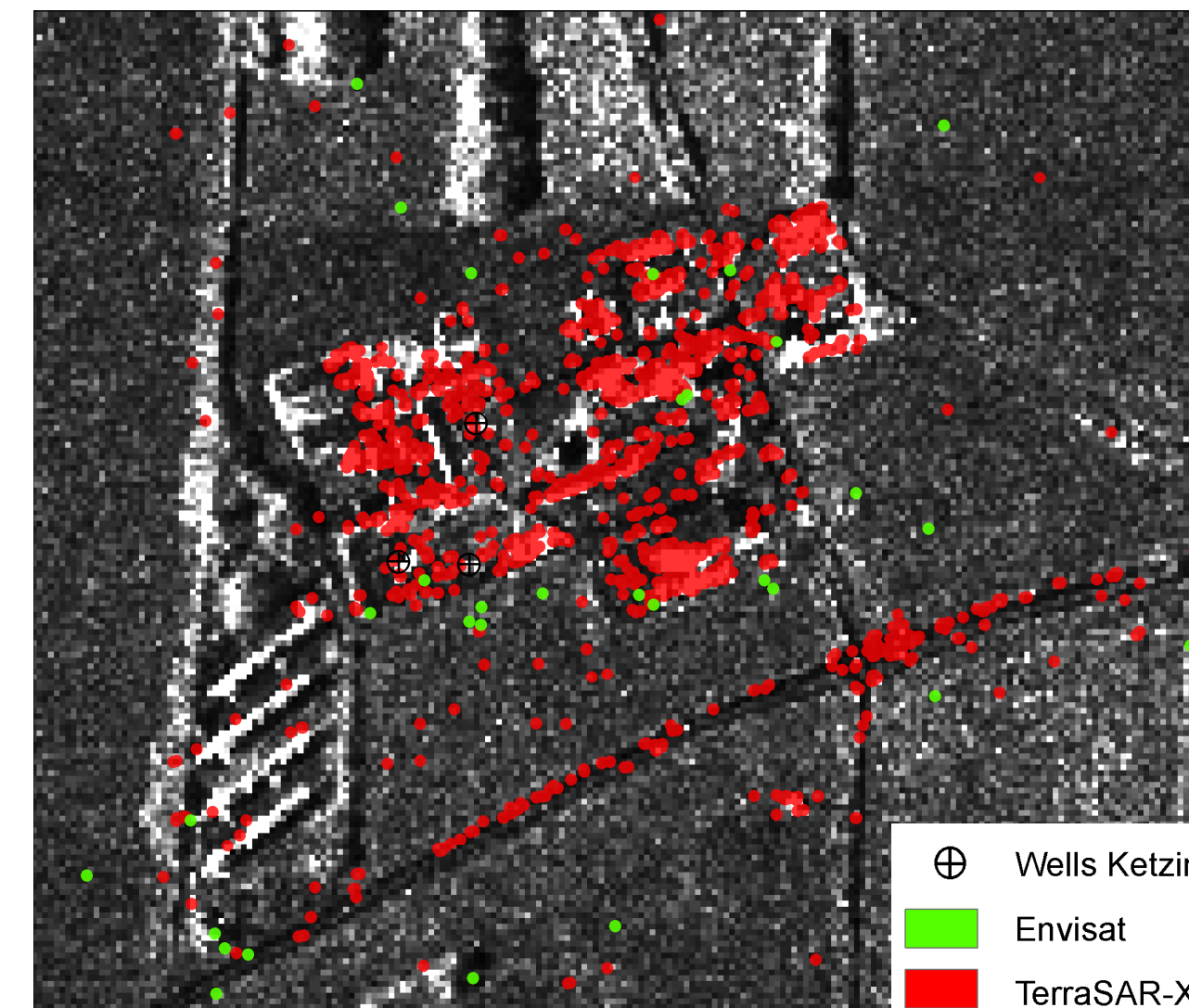


Figure 3: Point Density for different sensors

- PSI point density strongly increases in built-up areas with the use of higher resolution TerraSAR-X StripMap data (red dots) in comparison with the results achieved with ENVISAT ASAR data (green dots).
- Increase in PSI point density is not as high in agricultural fields: Nevertheless, additional PSI points can be found in between „islands“ of built-up areas (e.g. roads).

Figure 4 shows the current PSI result for Ketzin: So far, no significant surface movement trend can be derived for the time period between April and 10 and 11/2009.

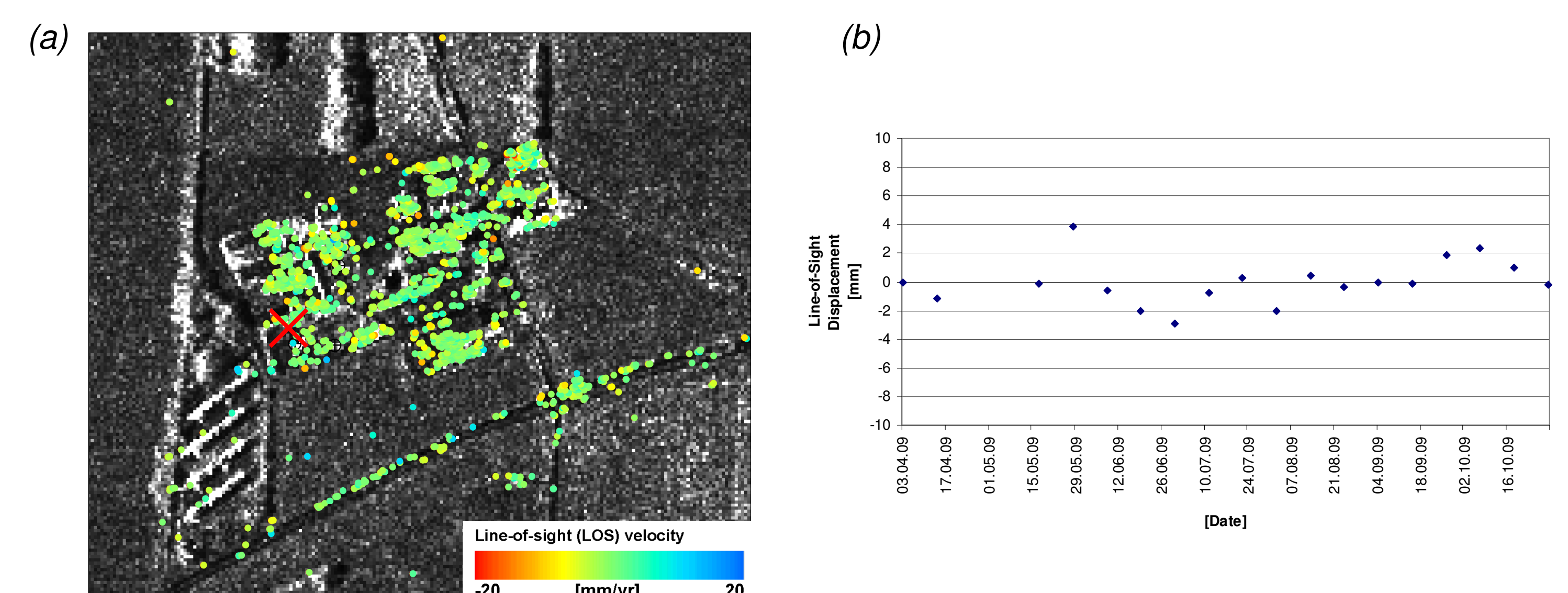


Figure 4: PSI result for Ketzin – (a) Line of sight velocity; (b) Sample time series of surface movements for the point indicated with a red cross in (a);

## 6. Conclusion

Use of high resolution SAR data from TerraSAR-X yields higher PSI point density, especially in built-up areas but also along features connecting different „islands“ of higher PSI point density. Higher PSI point density is important for different reasons:

- Improved potential for minimizing residual artifacts induced by atmospheric and other sources
- Increase in 2D information on surface movements and thus better potential for correlation with the spread of the underground CO<sub>2</sub> plume.

Smaller wavelength of TerraSAR-X enables improved sensitivity to smaller surface movement amplitude. Nevertheless, the current result from Ketzin does not show significant surface movements trends related to the CO<sub>2</sub> injection between 04/2009 and 11/2009. Sensitivity to small surface movements and strong potential for the correction of atmospheric and other phase residues is key as learned from experiences with In Salah and the work on natural gas storage sites signals.

→ The use of radarinterferometric derivation of surface movements related to CO<sub>2</sub> injection has strong potential also for Central European land cover conditions - especially if high resolution SAR data (e.g. from TerraSAR-X satellite) are used.

## 7. Outlook

Investigations will be continued on base of further high spatial resolution TerraSAR-X data:

1. The potential for the derivation of non-linear surface movement patterns will be further investigated: Key for the identification of areas, which are influenced by the injection of the CO<sub>2</sub> through correlation between pressure and surface movements.
2. New methods like Small Baseline Subset (SBAS) to be tested to further increase information content at more rural landscape as found in Central Europe.
3. Processing of corner reflector data available from Spring 2010.

## Acknowledgements

- Work supported by European Space Agency (ESA VAE Project „Carbon Capture Storage Monitoring for Energy Industry - using high resolution SAR (SAR4CCS)“).
- TerraSAR-X data provided by Infoterra GmbH.
- SARscape Software for DInSAR/PSI processing provided by CREASO and sarmap.

<sup>1</sup> lutz.petrat@infoterra-global.com, Phone +49 7545 8 3389

<sup>2</sup> jan.anderssohn@external.infoterra-global.com, Phone +49 331 2374 84 03

<sup>3</sup> michael.riedmann@infoterra-global.com, Phone +49 331 2374 84 03