

## SATELLITE SURVEILLANCE OF GROUND MOVEMENT

Marino Engineering continues to explore new technology in the area of ground subsidence, and as such we are now utilizing an exciting satellite surveillance technology called InSAR to track ground movement. This bulletin is an overview of that technique.

Conventional methods of monitoring subsidence such as field surveying and GPS measurements are necessary and are the most reliable first-hand estimates of land deformation. But they are time-consuming, expensive, and prior knowledge is often necessary. Compared to traditional techniques, Interferometric Synthetic Aperture Radar (InSAR) offers the potential advantage of providing fairly precise measurements of the magnitude and rate of subsidence over a large geographic area at a very competitive cost.

InSAR is a technique where digital elevation models are developed from measured path variations between the satellite position and the time of acquisition, which allows estimation of surface movement of the terrain. InSAR data has been collected over many parts of the world since the early 1990s. Consequently, the subsidence history of a project area from any cause can be reconstructed from the 1990s to date.

For example, Figure 1 shows the subsidence history from old underground coal workings of a known subsidence area in Springfield, IL for the periods of 1992 and 2000. The subsidence map was generated using C-band satellite data obtained from the European Space Agency (ERS-1/2) and is

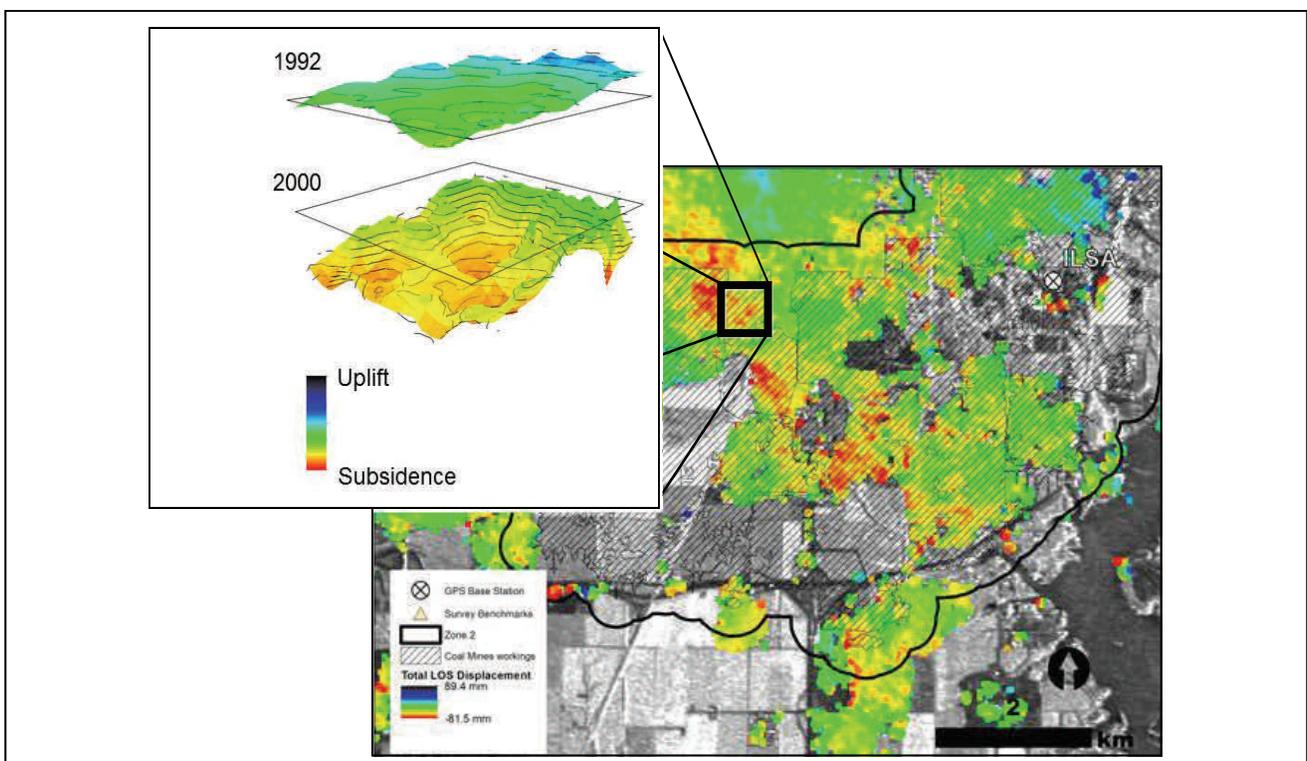


FIGURE 1 SUBSIDENCE HISTORY OF KNOWN SUBSIDENCE AREA IN SPRINGFIELD, IL

shown in Figure 1. Red spots on the map show the detected locations of subsidence. Note that smaller surface areas can be measured to obtain more accurate and location-specific measurements.

Figure 2 shows the average rate of subsidence from 2006-2010 over the St. Louis Metro area. Red indicates significant subsidence. Many subsiding zones detected by InSAR to the east of the city were confirmed with field surveys, but others have never been mapped or reported. A close-up view of any red point on the Google Earth map indicates that there is a past or ongoing surface deformation at the red areas. This example highlights the advantages of InSAR in mapping subsidence over large areas above abandoned or forgotten mines or other causes of subsidence (e.g. from karst).

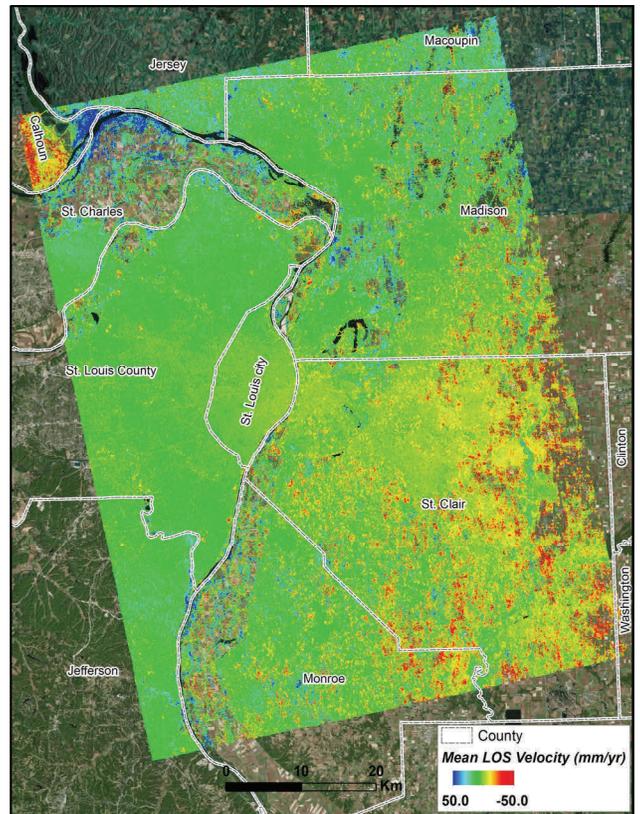


FIGURE 2 AVERAGE SUBSIDENCE 2006 TO 2010 OVER ST. LOUIS METRO AREA

InSAR may be able to measure both ground displacements on Earth's surface to the precision of a centimeter or less. InSAR data provides historic ground movements and current subsidence history over a large area at marginal cost compared to traditional surveying techniques. It has wide applications in detecting past and ongoing ground surface deformation and predicting "hotspots" of subsidence activity due to various causes such as ground heave, mining, karst, groundwater withdrawal, tunneling, landsliding, compressible or swelling foundation soils, etc.

## REFERENCES

Grzovic, M., Ghulam, A. (2015). Monitoring residual land subsidence due to underground coal mining using TimeSAR (SBAS and PSI) in Springfield, Illinois, USA. *Natural Hazards*, 79(3): 1739-1751.

Ghulam, A., Grzovic, M., Maimaitijiang, M., Sawut, M. (in press). InSAR monitoring of land subsidence for sustainable urban planning. In Weng, Q. (Eds.), *Remote Sensing for Sustainability*. Courtesy of CRC Press.

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### Other Engineering UPDATES of Interest:

**UPDATE 34: Risk Investigation of Karsts on Sinkhole-Subsidence Prone Lands**

**UPDATE 14: Establishing Mine Subsidence Risk**

**ABOUT MEA:** Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 24 states in the U.S. Our projects primarily have an emphasis on Geotechnical Engineering, however, we also have significant experience in projects involving transportation, subsidence engineering, laboratory testing, training, and geophysical exploration. Gennaro G. Marino, Ph.D., P.E., D.GE is president and principal engineer of Marino Engineering Associates, Inc., and has been a licensed professional engineer since 1984. To obtain additional information on MEA, one can also visit our website at [www.meacorporation.com](http://www.meacorporation.com).

**FOR MORE INFORMATION:** There is a significant amount of additional information that is available on the above subject. For more information, please contact Dr. Marino at the address listed below.