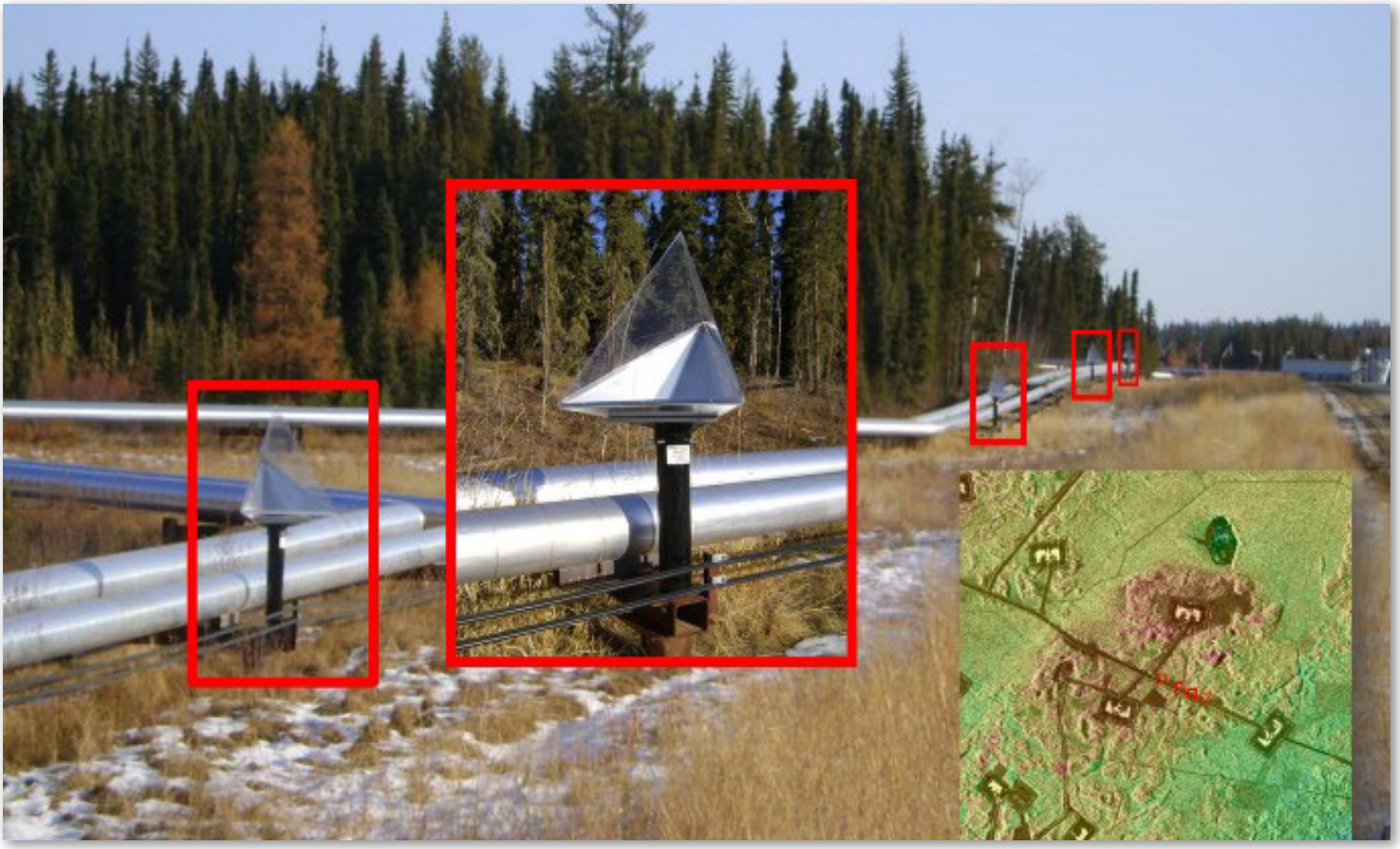

CASE STUDY

John Wessels
PCI Geomatics

Gordon Staples
MDA Corporation

Using InSAR for Steam Injection Monitoring in Cold Lake, Alberta

Leveraging GXL's rapid processing capability made it possible to optimize image selection from over 50,000 archive RapidEye images.

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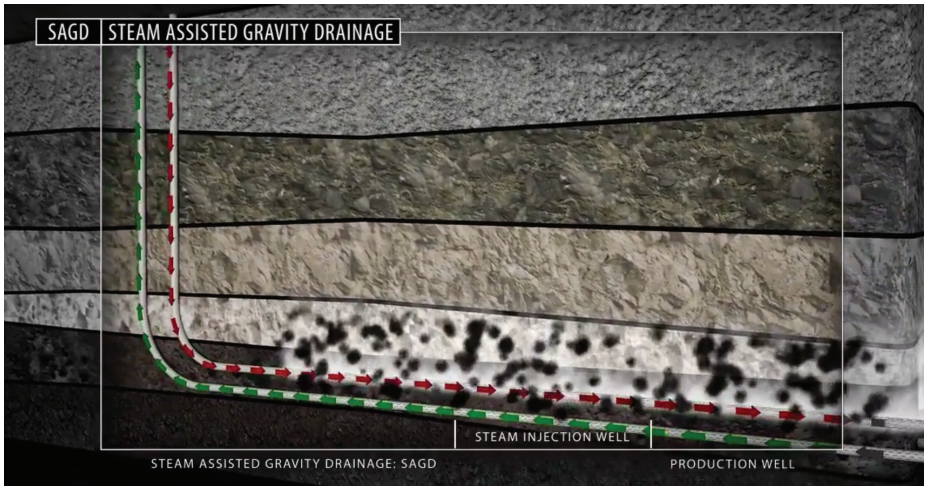
Overview

PCI Geomatics has been active in enhancing the utility of Interferometric Synthetic Aperture Radar (InSAR) technology by creating an easy-to-use, easy-to-learn processing system add-on module within the Geomatica 2017. In collaboration with MDA – a leading global communications and information company – PCI analyzed RADARSAT-2 InSAR imagery on an operational production oil production site located in in Cold Lake, Alberta. MDA previously installed corner reflectors along a key pipeline where cyclic steam stimulation is used to separate oil from sand in order to measure ground deformation. The Geomatica InSAR module was used to monitor the surface velocities and deformation of pipelines due to cyclic steam stimulation, and the results were compared to expected deformation values modeled by the client, as well as the previous InSAR measurements of MDA using the same imagery.

Cyclic Steam Injection

Imperial is one of Canada's largest refiners of petroleum products, with operations scattered across Alberta and Southern Ontario. The site located in Cold Lake, Alberta is their longest-running Albertan operation and among the world's largest thermal in-situ heavy oil enterprises. In Cold Lake, Imperial implements the CSS process to extract the soil's bitumen by injecting steam into the oil sands, which enables it to flow to the surface more efficiently. During the steam injection phase, the reservoir can undergo substantial dilation, resulting in a significant strain on the overburden. Overtime, this process causes terrain deformation, and therefore, a system is necessary to monitor the land shifting to prevent possible damage to the expensive, permanent equipment.



Why Corner Reflectors?

Due to the change land cover at the Cold Lake site, the only reliable method of measuring ground deformation is through the use of stable corner reflectors which act as target points. The ten reflectors along the Cold Lake pipeline provided adequate information to maintain the consistency of the dataset. Using Geomatica's InSAR module, the corner reflectors were monitored over a 6 month period - September 2009 through February 2010 - to validate the accuracy.

InSAR processing advantages

There are multiple reasons as to why InSAR technology is ideal for wide-scale deformation mapping. Its ability to measure elevation changes less than 1cm (down to the mm level) sets it apart from other sensors as this data is generally too small for other sensors to quantify. Ground surveying of point locations using qualified personnel that need to respect safety codes can be problematic. By using satellite imaging technology and corner reflectors, the need for on-site personnel can be minimized, and the number of measurements can be increased by increasing the collection frequency.

InSAR can also generate accurate digital elevation models (DEM) regardless of cloud cover and weather conditions. This technology is not only useful for the oil and gas industry, but also for ground industries such as: mining, urban construction, slope monitoring, volcano monitoring and other applications.

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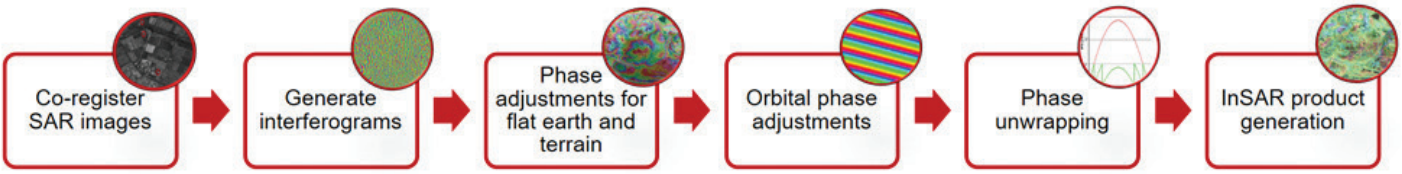
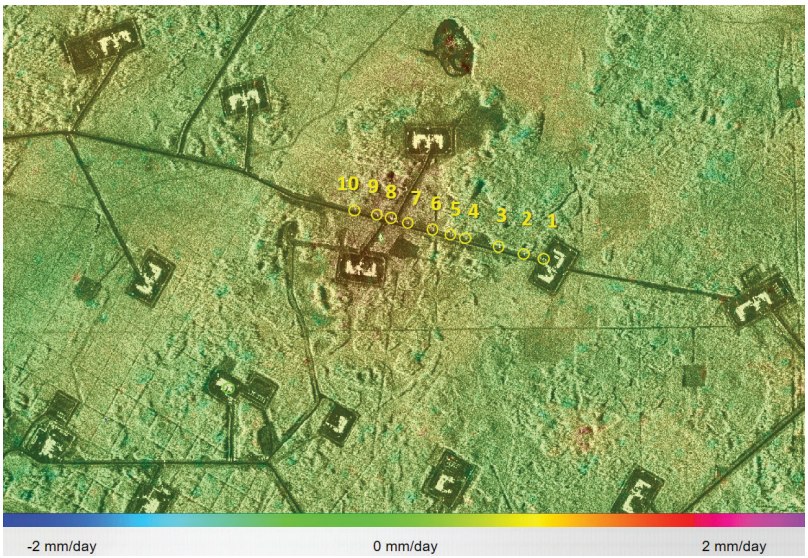
Processing Workflow

The new InSAR add-on module in Geomatica 2017 was designed with ease of use in mind. Each step in the InSAR process is designed to be flexible, intuitive, and run independently or in sequence through the Geomatica Python APS, with default parameters to aid with automation. Using commercially available data such as RADARSAT-2 and TerraSAR-X, Geomatica InSAR is suitable for any land deformation application and allows time series analysis for measuring change and rates across image stacks.



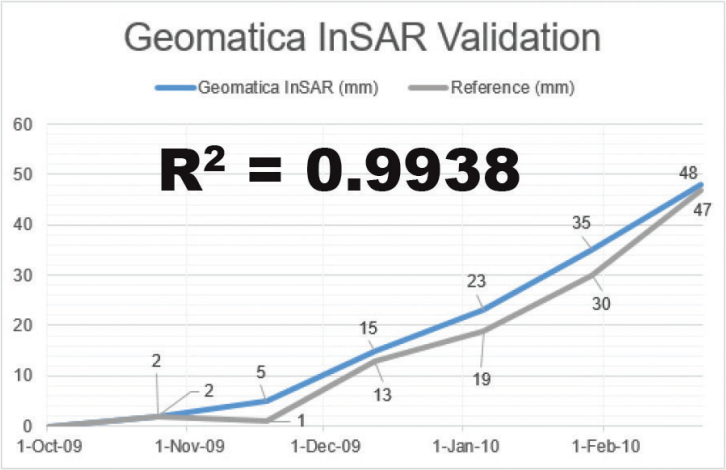
Measuring velocity rates based on stable areas

Once all inteferograms have adjusted and only residual deformation information remains, measuring the deformation rates must be accomplished. PCI Geomatics provides the user with maximum flexibility in this regard, by allowing the selection of known stable areas in order to perform relative deformation rates. The user can select known stable areas, and the InSAR measurements will be adjusted relative to these areas. Both cumulative displacement and velocity of displacement can be measured through Geomatica InSAR, which is fully integrated within the Geomatica processing environment.



Accuracy and Validation Assessment

Prior to running the RADARSAT-2 imagery through Geomatica's InSAR module, an the in situ model was generated to act as a starting point. A predicted model was also provided by Imperial, outlining how the deformation trend should appear based on geophysical models. This model acted as the basis for validating the accuracy of the InSAR output stack. Although coherence was low across the area of interest (due to the vegetation and snow cover in this location), the corner reflectors were isolated and the deformation measurements were extracted using the stacking capability for the InSAR images. The following graph shows strong agreement between the geophysical model's predicted deformation pattern over one of the ten corner reflectors and the measurements extracted from Geomatica InSAR. In fact, the correlation of the two trend lines are very strong, with and R2 value of 0.9938.



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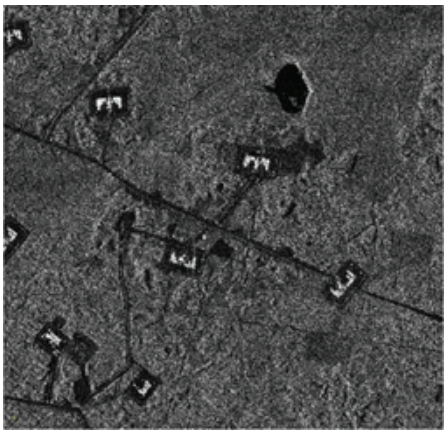
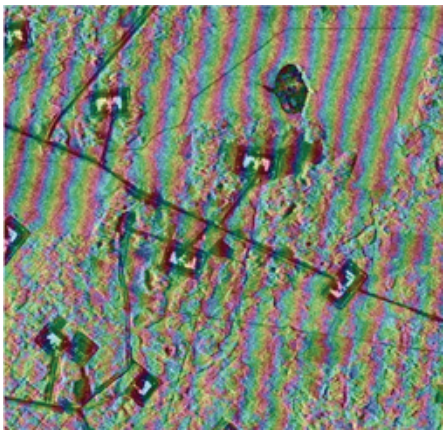
Intermediary Products - Cold Lake, Alberta

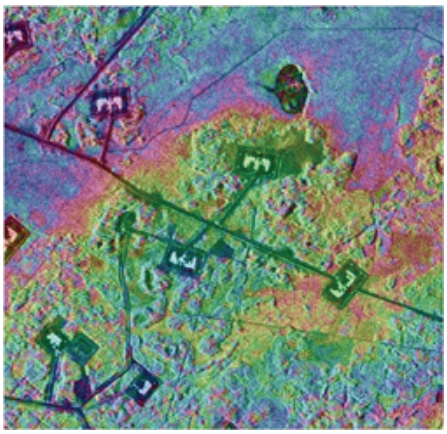
Calibrated Intensity

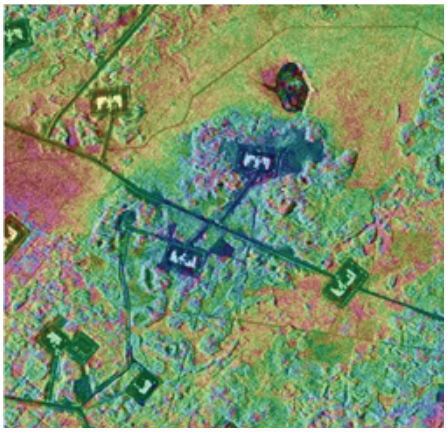


Raw Interferogram and Coherence

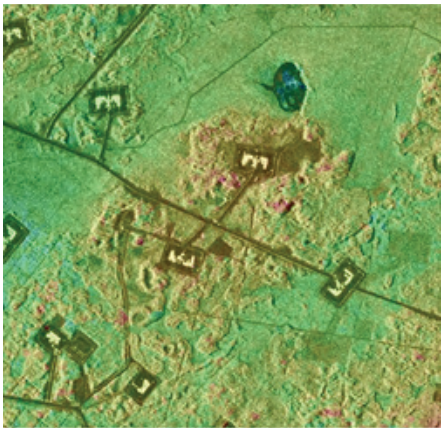


Flat Earth and Topographic Phase Removal

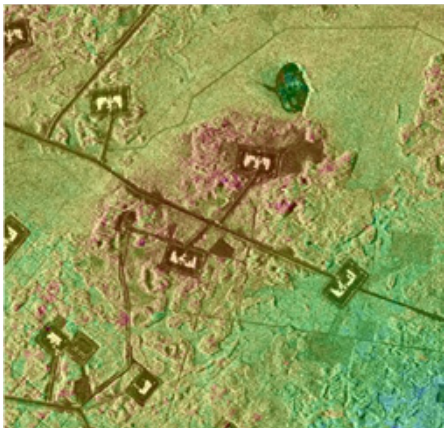




Orbital Adjustment



Phase Unwrapping



Atmospheric and Noise Adjustment

About PCI Geomatics

PCI Geomatics is a world-leading developer of software and systems for remote sensing, spatial image processing, and photogrammetry. With more than 30 years of experience in the geospatial industry, PCI is recognized globally for its excellence in providing software for accurately and rapidly processing satellite and aerial imagery. There are more than 30,000 PCI licenses, in over 150 countries worldwide. Find out more about PCI Geomatics at www.pcigeomatics.com.

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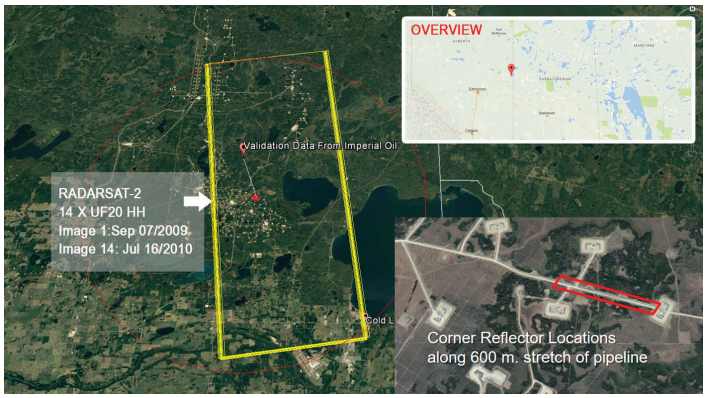
Study Area (Cold Lake, Alberta)



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