White Paper

Utilizing Free Use Satellite Images and Remote Sensing Software to Detect Landslides

Examining the Amyntaio Mine, Ptolemaida, Greece

The Power Portfolio from Hexagon Geospatial combines the best photogrammetry, remote sensing, GIS and cartography technologies available. Flowing seamlessly from the desktop to server-based solutions, these technologies specialize in data organization, automated geoprocessing, spatial data infrastructure, workflow optimization, web editing, and web mapping.

The Producer Suite enables you to intelligently author, analyze, process, and map multiple sources of data.

12 July 2019

HEXAGON

Contents

Abstract

Landslides can happen without warning and having the data to decide next steps after they occur is imperative. With the continued emergence of free-use data such as that from the Copernicus/ESA program, decision-making has become easier. This data, with its high temporal frequency, spatial accuracy and broad coverage, provides a solid base to work from. Multimodal approaches, such as combining information from optical and radar sensors like the Sentinel-1 and Sentinel-2 satellites, can lead to improved accuracy, detection and verification of landslide phenomena.

This paper aims to demonstrate that process by combining Sentinel-1 and Sentinel-2 data in rapid and automated processes. Then, several change detection algorithms in ERDAS IMAGINE remote sensing software will be used to analyse that data and easily create a visual representation of the activity surrounding the landslide.

Reducing Hazardous Situations

Landslides can be triggered by natural occurrences, such as rain or earthquakes, or manufactured causes, including deforestation or excavation. Having an accurate, rapid and automated detection system can mean the difference between the ability to base decision-making on timely information or simply guessing at the level of damage resulting from the incident.

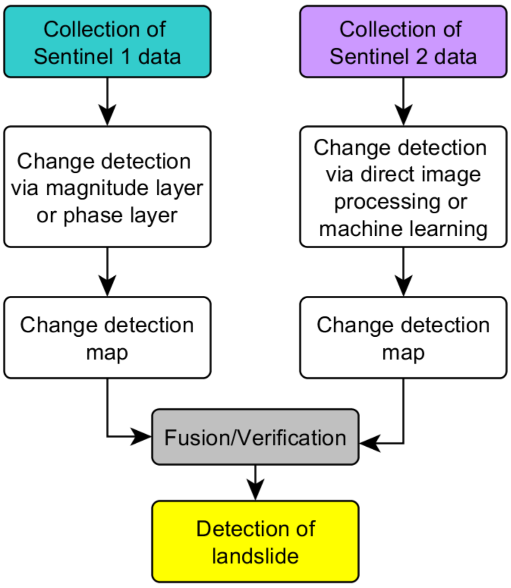
For example, landslides are a constant threat in open pit mines. Monitoring the slope of mine walls and thresholds can not only aid in verifying landslides but can also assist in predicting if and when they will occur. Timely and accurate analysis of the landslide can be invaluable in planning and executing all rescue and reparation activities in the affected areas. Such information is invaluable to anyone who monitors or makes decisions concerning mine activity.

On 10 June 2017, the Amyntaio mine, a lignite coal mine in Western Macedonia, Greece, suffered a massive landslide, resulting in large masses of soil being detached and moved. Mining equipment was also lost, but fortunately, no lives were taken. We will look at data from this landslide to demonstrate how ERDAS IMAGINE enables the detection and analysis of a landslide by fusing radar and optical imagery from open-source data.

Using Open Access Data with ERDAS IMAGINE

Because of the availability of open access information, we have a variety of data available for processing and analysis in ERDAS IMAGINE. As the world's most widely-used remote sensing software package, it can ingest and convert data to over 190 image formats. This allows the processing engine to operate on the timeliest data without file format restrictions.

In using the data from the Amyntaio example with ERDAS IMAGINE, the following methodology will be used:



Copernicus/ESA Program

Through Copernicus, six Sentinel programs are employed to collect satellite data of Earth. Each program collects mission-specific information and focuses in a unique way. The following chart displays a comparison of Sentinel-1 and Sentinel-2 satellites as well as the information they are used to gather:

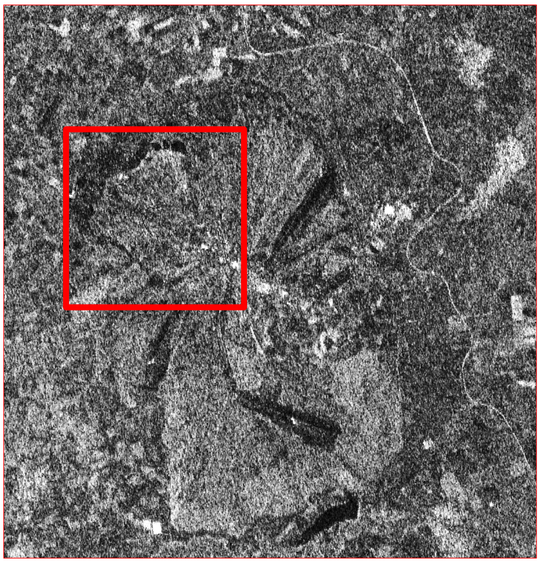
Facts and Figures	Sentinel-1	Sentinel-2
Launch Date:	Sentinel-1A, 3 April 2014 Sentinel-1B, 25 April 2016	Sentinel-2A, 23 June 2015 Sentinel-2B, 7 March 2017
Data Type:	Radar Data	Optical Data
Main Applications:	Monitoring sea ice, oil spills, marine winds, waves & currents, land-use change, land deformation; respond to emergencies such as floods and earthquakes	Monitoring agriculture, forests, land-use and cover change; mapping biophysical variables such as leaf chlorophyll content; monitoring coastal and inland waters; risk mapping and disaster mapping
Instrument:	C-band synthetic aperture radar (SAR) at 5.405 GHz	Multispectral imagery covering 13 spectral bands
Revisit Time:	6 days	5 days from two-satellite constellation (at equator)
Orbit:	Polar, Sun-synchronous at an altitude of 693 km	Polar, Sun-synchronous at altitude 786 km

Information compiled from the Copernicus page of the ESA website

To detect the Amyntaio mine landslide, we downloaded time-series Sentinel-1 and Sentinel-2 images from the Copernicus Open Access Hub. It should be noted that users must register and log-in to access the data.

The following are examples of Sentinel-1 data from Copernicus collected from the Amyntaio mine landslide:

From sentinel-1B, 4 June 2017 (before event)



From Sentinel-1A, 10 June 2017 (shortly after event)

To demonstrate use of the Sentinel-1 data (SAR data), two change detection maps of the landslide will be extracted. The first will be extracted using the magnitude layer, while the second will use the phase layer via interferometry. Concerning the Sentinel-2 data, two more maps will be extracted. The first will use direct image processing, while the second will use machine learning.

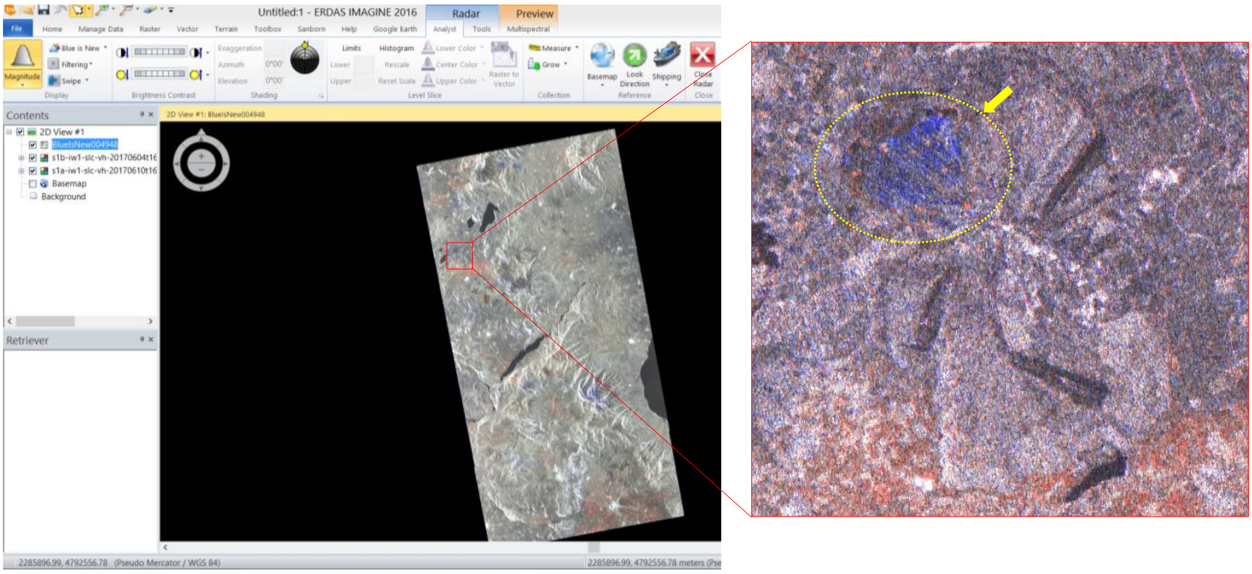
Change Detection with Sentinel-1 Radar Data

The Magnitude Layer

In the radar data, the Magnitude layer is the closest to what we think of as an "image." Using this layer in the ERDAS IMAGINE Radar Analyst tool, we can rapidly create a change detection map from the two radar datasets. Using the "Blue is New" algorithm, we can get a quick visual representation of the area affected by the landslide.

The below figure depicts a significant change associated with the landslide colored in blue (dashed ellipse in yellow).

HEXAGON

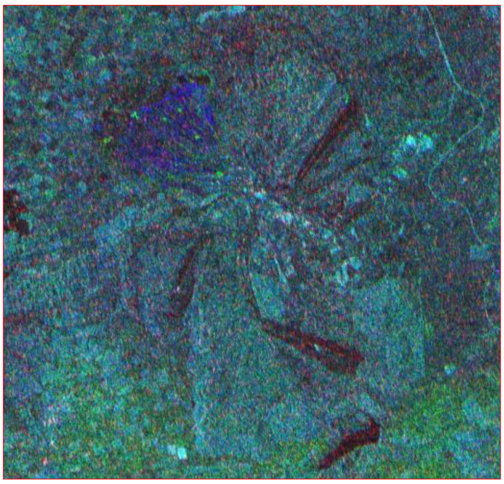


The blue pixels provide a visual indication of where pixel values change between the magnitude images.

The Phase Layer

The Phase layer of the radar data is nothing like a traditional image and requires rigorous computer algorithms to convert the data into meaningful imagery. The IMAGINE SAR Interferometry add-on provides the necessary toolkit for unwrapping the data. The Coherence Change Detection (CCD) algorithm can be used to identify changes in elevation represented in the data to within a few millimeters. This sort of accuracy can be crucial when analysing landslide information.

Once we run the CCD, we can create a Multitemporal Coherence Map. The resulting map shows significant change associated with the landslide is detected (in blue).



The dashed ellipse indicates where the greatest amount of change occurred between the phase data.

Change Detection Using Sentinel-2 Optical Data

Obtaining the Data

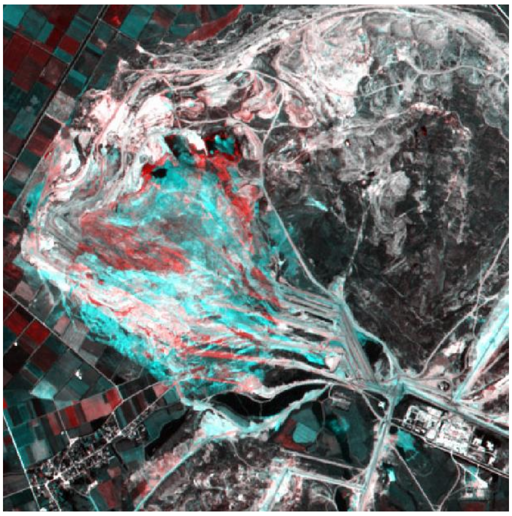
For this example, we layer-stacked the data to create an RGB-NIR image of each Sentinel-2 dataset.

After downloading the Sentinel-2 data, which contains 13 spectral bands, we combined Band 2, Band 3, Band 4 and Band 8 in the pre-landslide imagery to create the first layer-stacked image. Then, the same bands from the post-landslide data were layer-stacked to create the second image. The following images show each RGB-NIR image of the before-and-after data.

Direct Image Processing

After creating and saving an area of interest (AOI), the Change Detection tool and Site Monitoring algorithm can be used on the stacked images and the AOI file.

The change detection results extracted through direct image processing are shown in the following figure. An indication of a significant change is detected (dashed ellipse in yellow), associated with the landslide.



Areas of red and blue indicate places where significant change occurred.

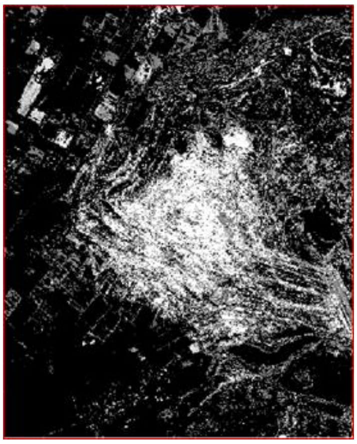
Machine Learning

In many cases, the computer can identify changes that a human operator might not spot. Machine learning, like IMAGINE Objective, can be used to automatically extract the changed areas from the datasets. The Raster Pixel Processor can also be used to compute the probability metric (a number between 0 and 1) that each pixel has changed.

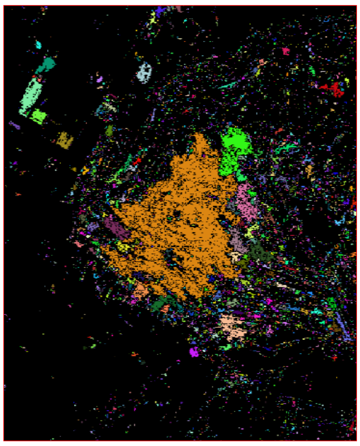
Pixels which have the higher probability of change are assigned values closer to 1, while pixels which have lower probability of change are assigned values closer to 0.

The extracted change detection results (i.e. the probability image and the Threshold and Clump image) can be viewed in ERDAS IMAGINE's viewer.

The following figure shows the extracted probability map which indicates a significant change associated with the landslide (dashed ellipse in yellow).



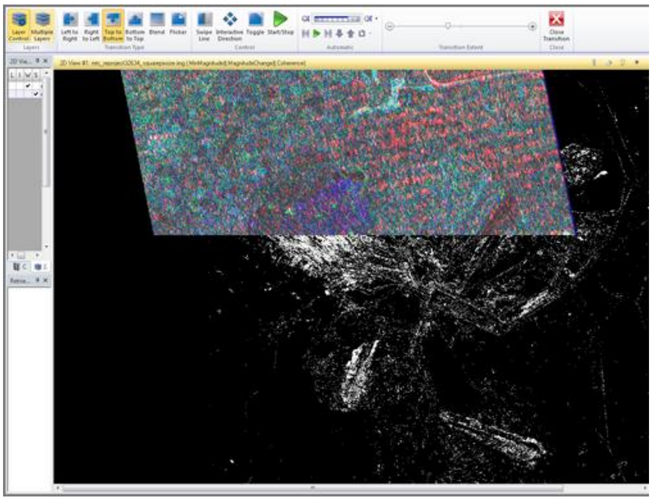
The pixels with the highest probability of change appear brighter in the output image.

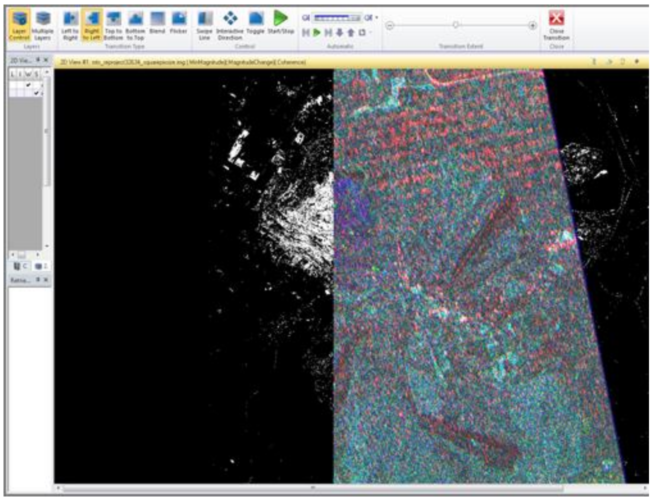


This image has had all the small areas of change removed to focus on the major changes.

Fusing the Data

The extracted landslide detection results from Sentinel-1 and Sentinel-2 processes can be seen by using the ERDAS IMAGINE's Swipe tool (as demonstrated in the following images):





Conclusion

This paper proposes a synergistic landslide detection framework using Sentinel-1 and Sentinel-2 data and applying several change detection algorithms in ERDAS IMAGINE. The Amyntaio mine landslide in Greece on 10 June 2017 was selected to demonstrate this ability. The landslide was rapidly and effectively detected through operational and automated processes. Thus, rapid and reliable conclusions can be extracted for decision-making and risk monitoring for mines and other landscapes.

Contact us

For more information, please contact us at:

marketing.us.gsp@hexagon.com

+1 877 463 7327

https://go.hexagongeospatial.com/contact-us-today

About Hexagon

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's Geospatial division creates solutions that deliver a 5D smart digital reality with insight into what was, what is, what could be, what should be, and ultimately, what will be.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 20,000 employees in 50 countries and net sales of approximately 4.3bn USD. Learn more at hexagon.com and follow us @HexagonAB.