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Using Sentinel-1 and -2 for Change Detection in Facilities Safeguarded by Euratom

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Remote sensing information collected by the European Commission's Copernicus programme, namely from the Sentinel-1 and Sentinel-2 satellites, bears potential for change detection analysis over nuclear facilities. This poster demonstrates some workflows for obtaining, processing and analyzing Sentinel-1 and -2 data for change detection analysis for nuclear facilities within the European Union. Such change detection analysis gives Euratom a tool for monitoring the nuclear facilities using freely available software and algorithms.

Freely available remote sensing data offers international safeguards inspectorates the opportunity to perform change detection analysis before or after visiting a facility. Remote sensing data has proven to be valuable to international safeguards inspections for the past 2 decades. Freely available software and datasets are now making such analysis more comfortable for inspectorates. This poster illustrates some of the possible ways such datasets can be analyzed using open source platform and open source change detection.

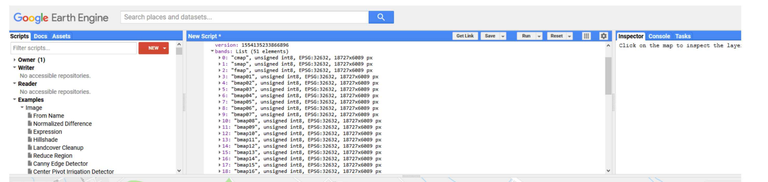


Figure 1 | Screenshot of the Google Earth Engine Code Editor. Map data ©2018 Google

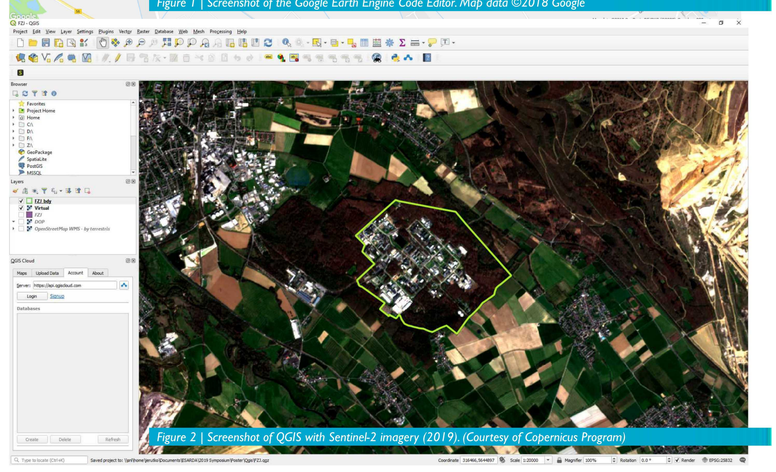


Figure 2 | Screenshot of QGIS with Sentinel-2 imagery (2019). (Courtesy of Copernicus Program)

ALGORITHMS and PLATFORMS:

The Algorithms

Change detection has been instrumental in remote sensing for more than four decades; as such, a wide range of approaches has emerged. Some methods particularly attractive for safeguards applications require minimal user interaction and use simple and empirical formulations:

Omnibus change in radar time-series
(Conradsen et al. 2016)

Statistical tests can indicate whether at least one change has taken place in a time series of radar images. Once a change is found in a time series, its timing can be determined by successively testing subsets of the entire series, which provides an advantage for safeguards applications by enabling rapid screening of a large number of radar images.

Imagine differencing

Imagine differencing, one of the simplest ways of highlighting change in an image, is nevertheless highly effective. Subtracting a later image from an earlier image highlights spectral changes in a scene.

The Platforms

Computing change detection for remote sensing datasets requires data, algorithms as well as a platform. Google Earth Engine offers users the option to perform calculations using cloud computing and data storage through a browser interface (see Figure 1). Using a Docker container, users may perform similar calculations using a desktop client or server, see http://mortcanty.github.io/src/ or (Canty 2019) for more examples. Desktop application, like QGIS (http://qgis.osgeo.org/) are also commonly used (Figure 2). Each of the options shown here demonstrate viable ways to perform change detection on Sentinel data using the open source algorithms.

DATA and RESULTS:

Data

The Copernicus programme is a joint initiative of the European Commission in partnership with the European Space Agency. All imagery from this programme is free and available for download over the Internet at *https://scihub.copernicus.eu/*. Key satellite constellations for safeguards applications are:

Satellite	Sentinel-1	Sentinel-2
Number of satellites in constellation	2	2
First Launch	3 April 2014	23 June 2015
Sensor Type	Interferometric Synthetic Aperture Radar (SAR)	Multispectral
Wavelength Region	C-Band	Visible, Near and Shortwave IR (13 bands)
Spatial Resolution (m)	5-100	10-60
Revisit Frequency (nominal)	6 days	5 days
Safeguards Applications	• All-weather, day and night, imaging • Elevation change	• Land cover change

Other open source data

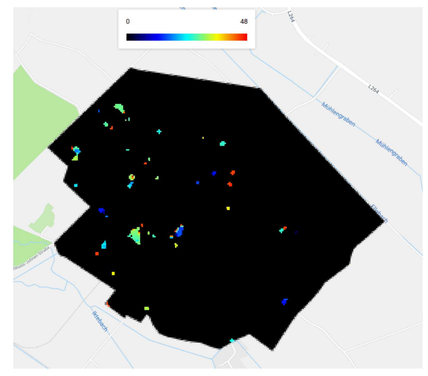
A wide variety of open source digital geographic information is available. These open source data provide valuable geospatial context for image interpretation.

- *OpenStreetMap* is an online, volunteer community who develop geospatial data, including roads, trails, restaurants, etc, all over the world, using GPS and imagery. *https://www.openstreetmap.org*.
- *Orthophotos*. Many national, regional, and local governments provide orthophotos online. Google Earth *https://www.google.com/earth/* has a large store of current and historical satellite and aerial imagery.

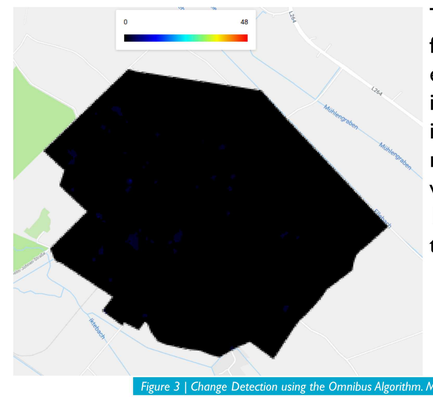
Results

It is possible to use only open-source software to perform simple to complex change detection on remote sensing data. Users can visualize the results through platforms outlined above. For the case study, Forschungszentrum Jülich in Germany, the resulting change detection maps and ancillary data are shown at right. The omnibus algorithm in Google Earth Engine summarizes the changes in each scene as depicted in Figure 3. Image differencing, as shown by Figure 5, provides a rapid method for screening images for changes and also indicates the types of changes.

May 2018 – April 2019 Change Detection



This map shows the color-coded times of the most recent change observed in the area of interest, blue early in the time series, red late. There were 48 scenes considered in the change detection algorithm.



This map shows the frequency of change for each pixel in the area of interest, blue colors indicate few changes, red many. Most changes were only observed in 1 to 4 scenes, hence the dark colors.

Figure 3 | Change Detection using the Omnibus Algorithm. Map data ©2018 Google

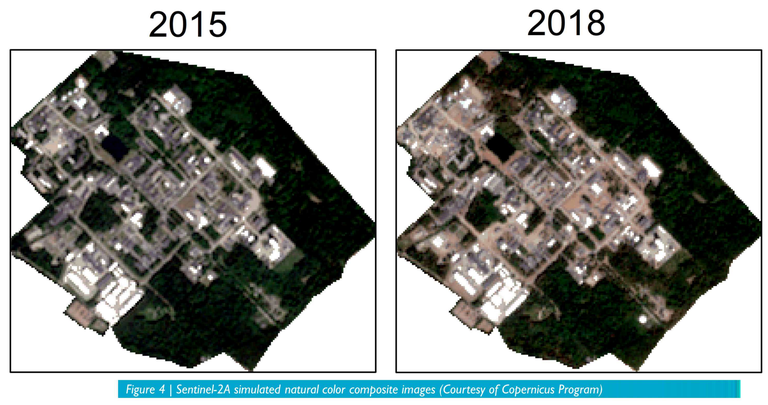


Figure 4 | Sentinel-2A simulated natural color composite images (Courtesy of Copernicus Program)

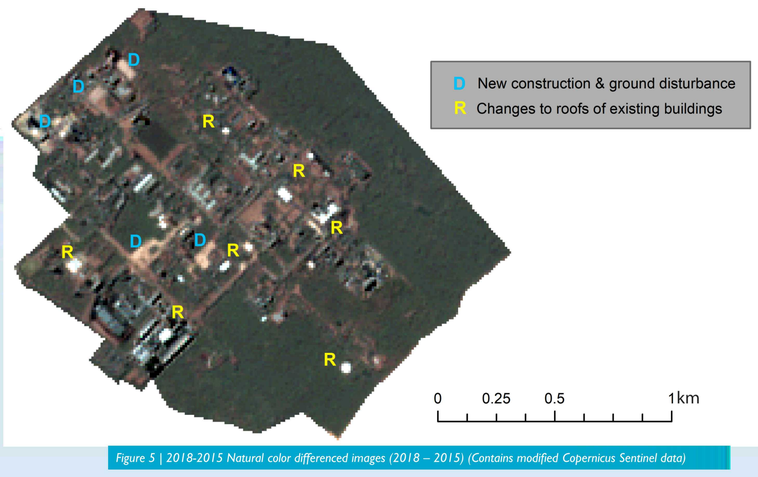


Figure 5 | 2018-2015 Natural color differenced images (2018 – 2015) (Contains modified Copernicus Sentinel data)

REFERENCES:

Conradsen, K., Nielsen, A. A., & Skriver, H., 2016. Determining the points of change in time series of polarimetric SAR data. IEEE Transactions on Geoscience and Remote Sensing 54(5): 3007-3024.

Canty, M. J. ,2019. Image Analysis, Classification and Change Detection in Remote Sensing: With Algorithms for Python. CRC Press.

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