POLITIQUE SCIENTIFIQUE FEDERALE - FEDERAAL WETENSCHAPSBELEID

RESEARCH PROGRAMME FOR EARTH OBSERVATION STEREO III

FINAL REPORT

CONTRACT SR/00/372

SARSAR

Automatic redevelopment sites monitoring using SAR and OPTICAL images

Date: 30/11/2021

Direction de l'Aménagement opérationnel et de la Ville (DAOV) - Service public de Wallonie
Royal Military Academy (RMA)
Institut Scientifique de Service Public (ISSeP)

1 CONTENT

2 PROJECT INFORMATION

DURATION[1]

01122018 - 30092021

Prolongation requested for additional time in order to complete the WP4 (technology transfer) in the best possible conditions given the sanitary situation due to Covid-19.

STAFF / CHANGES IN STAFF[2]

NAMES AND JOB SITUATION AT THE END OF THE PROJECT

Service public de Wallonie - Territoire - Direction de l'Aménagement opérationnel et de la Ville (DAOV) :

Christophe RASUMNY, Administrative Officer

Royal Military Academy (RMA):

Xavier NEYT, Full professor

Mattia STASOLLA, Researcher

Institut Scientifique de Service Public (ISSeP) :

Eric HALLOT, Head of Unit

Sophie PETIT, Researcher

Gérard SWINNEN, Researcher

Additional staff member:

Name: Coraline WYARD
E-mail: c.wyard@issep.be
Type of position: Researcher
Type of contract: permanent contract

MISSIONS[3]: STAYS AT PARTNERS'S ORGANISATION, MEETINGS AND CONFERENCES

Name staff member(s): Sophie Petit

Assignment: "The Potential of SAR and OPTICAL Sentinel Images for the Automatic Monitoring of Redevelopment Sites", presentation at the EARSeL joint workshop, Liège, Belgium.

[1] State whether and why project was prolonged
[2] Per partner
[3] Since last activity report

Date: March 2021

Name staff member(s): Mattia Stasolla

Assignment: "Urban Sites Change Detection by Means of Sentinel-1 and Sentinel-2 Time Series", presentation at the 41st annual IGARSS symposium, Brussels, Belgium.

Date: July 2021

3 SUMMARY OF RESULTS[4]

3.1 OVERVIEW OF ACTIVITIES AND ACHIEVEMENTS[5]

WP1– USERS' NEEDS

WP1 was dedicated to the establishment of detailed requirements for the service. This was done by analysing the users' needs and verifying if the requirements fulfil the users' needs and, if not, to modify them accordingly.

An initial face-to-face meeting was held in July 2019 between ISSeP and DAOV, the future user of the tool, to determine the users' needs as precisely as possible. Subsequently, several phone meetings between DAOV, ISSeP, and RMA were set up to consolidate these needs, resulting in the D1.1 report. The latter was presented at the Steering Committee meeting on September 26, 2019.

In addition, online meetings were held during the summer of 2021 to fine-tune the user's requirements for the delivery of the final results.

WP2 – DYNAMIC MONITORING OF REDEVELOPMENT SITES

The first part of the WP2 was devoted to the extraction of relevant features from SAR and optical images used to detect changes in the RDSs. The development was initially carried out separately for Sentinel-1 and Sentinel-2 images, by RMA and ISSeP respectively and was conducted on 20 tests sites.

Then several change detection and classification methodologies were investigated and, the first phase of these investigations was presented in the activity report. The following phase was described during the Steering Committee meeting on March 19, 2021, for which the presentation is available.

[4] Give a summary of the activities and describe to what extent objectives were met – list problems encountered and how they were solved - lessons learned / experience gained - / - a detailed description of the results can be put in annex

[5] Make a distinction between scientific and operational activities and achievements

The second part of the WP2 consisted on fine-tuning the methodologies based on the Steering Committee feedback and WP3 performance results.

WP3 – VALIDATION AND PLATFORM INTEGRATION

The first part of this WP is devoted to the validation of the methodology and the results. In this context, a detailed performance assessment, in order to validate the results was done. For this analysis, two sets of ground truth have been created by visual analysis. The first ground truth is based on the orthophotos (25 cm resolution) taken in summer 2016 and 2018, and focuses on the RDSs for which there are major changes that can be observed from Sentinel data. The second ground truth is based on Pléiades images (50 cm resolution) acquired monthly between January 2019 and December 2020 on two specific areas with a high concentration of RDSs. This dataset was created to take into account in a more balanced way the different types of change. In addition, it also provides the ability to report, with a certain accuracy, the change dates. The performance assessment report (D3.1) explains all the final results.

The second part of this WP is dedicated to the platform integration (D3.2 – EO service for the dynamic monitoring of redevelopment sites). The platform used for automation of the SARSAR processing chain is TERRASCOPE to which we added a PostGIS server. This server is set up to feed itself with preprocessed S1 and S2 images. Python scripts were created to ensure each step of the SARSAR processing chain, namely:

- update of S1 and S2 image time series for each site;
- calculation of index time series based on this image time series;
- detection of change dates;
- classification of detected changes;
- calculation of confidence index in the detection and characterization of changes;
- establishment, based on the confidence index, of the priority of sites to be investigated;
- sending of the results by mail.

WP4 – TECHNOLOGY TRANSFER

A user manual (D4.1) was written so that the end-user can use the tool, understand its results and its limitations. It also describes the environmental requirements (IT infrastructure) and how it works. Appendix D of the user manual (D4.1) provides a detailed description of the use of the SARSAR tool within the TERRASCOPE environment, and the structure of the SARSAR database. In addition, commented Jupyter Notebooks are also provided to potential users of the SARSAR tool, on the one hand, to ensure the technology transfer (tutorials) and, on the other hand, to master and be able to restart each module of the SARSAR processing chain.

A training session was held on September 30, 2021 on how to use the tool. This session included several parts. The first one focused on the presentation of the change detection and classification

methodologies and of the technological environment on TERRASCOPE. The second part showed the different limitations of the methodologies and the results, also presented in the WP3 D3.1 Performance assessment report. The last part explained how the results are presented and how to understand and interpret them. This part was illustrated by examples.

The overall purpose of the training session was to explain to the entire DAO team:

- the ins and outs of the project
- the limits of the method (spatial and temporal)
- how the results should be interpreted according to the different scenarios
- how the information can be fed back to fine-tune the systems to make the results more operational

When the system will work automatically, the different roles will be distributed as follows:

- The ISSeP will have a technical role:
    - Check that everything is properly working
    - Respond to automatic alerts sent by the system (breakdown, disk space, various errors, etc.)
    - Plan fin-tuning according to the longer term feedback from the DAO.

- The DAO will work on the background and with the information received:
    - Continuous updating of the SAR database
    - Preparation of the work schedule for the field teams according to the sites defined as priorities
    - Follow-up of the list of sites to be monitored (addition of new sites and removal of sites that are no longer SARs)

WP5 – DISSEMINATION

Several activities have been held since the start of the project. The list of these activities is available in the activity-report and in section 6 of this report.

3.2 REALISATION OF OBJECTIVES[6]

The overall project goal was to perform change detection using SAR & optical images to identify whether a change occurred in a RDS and, whenever possible, identify the type of change using SAR & optical images. The objective was to develop a (set of) routine(s) that, with as little manual intervention as possible, provides a report of the changes that occurred between two indicated dates over the sites that are described as a set of polygons using the time-series of feature vectors extracted from Sentinel 1 & 2 images comprised between the two dates. The more detailed deliverables, together with their objectives where relevant, are presented in the table below, including information on their achievement.

[6] Provide table with objectives and deliverables and indicate whether achieved: YES, NO, PARTIALLY

It should be noted that all of the scripts are functional, but some still require manipulation or modification of the Jupyter Notebooks. As TERRA2SAR (see section 7), the project for SARSAR dissemination and compatibility with platforms such as GitHub, will start end of the current year, the improvement of the Jupyter Notebooks will be done in the framework of that project.

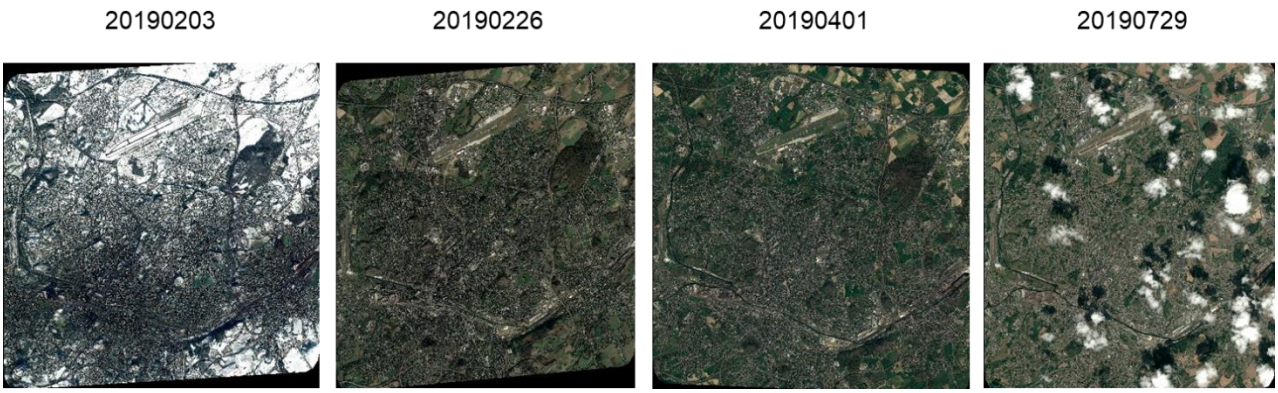
Deliverable	Objective	Achievement	Comment
D1.1 User Requirements Document		YES	
D2.1 Tool for the dynamic monitoring of redevelopment sites	Change detection methodology based on SAR & optical images	YES	
D2.1 Tool for the dynamic monitoring of redevelopment sites	Change classification based on SAR & optical images	YES	
D2.1 Tool for the dynamic monitoring of redevelopment sites	Indication on the amplitude and confidence of the change	YES	
D3.1 Performance assessment report		YES	
D3.2 EO service for the dynamic monitoring of redevelopment sites	Development of a set of routine to provide reports in an easy-to-use format	YES	Will be fine-tuned, for the upgraded TERRASCOPE configuration, in the TERRA2SAR project
D3.2 EO service for the dynamic monitoring of redevelopment sites	Development of a set of routine to extract features vectors from Sentinel-1 & Sentinel-2	YES	Will be fine-tuned, for the upgraded TERRASCOPE configuration, in the TERRA2SAR project
D3.2 EO service for the dynamic monitoring of redevelopment sites	Development of a set of routine to create time-series	YES	Will be fine-tuned, for the upgraded TERRASCOPE configuration, in the TERRA2SAR project
D3.2 EO service for the dynamic monitoring of redevelopment sites	Routines implemented on TERRASCOPE	YES	Will be fine-tuned, for the upgraded TERRASCOPE configuration, in the TERRA2SAR project
D4.1 User manual		YES	
D4.2 Hands-on training session on how to use the tool		YES	Done the 30th of September 2021
D5.1 User workshop for the		PARTIALLY	First workshop on

Walloon Region			November 26, 2019. Second will be planned in 2022
D5.2 Draft paper on dynamic monitoring of redevelopment sites		YES	- Conference paper published - Journal paper in preparation

3.3 PROBLEMS ENCOUNTERED AND SOLUTIONS

The main problem encountered, linked to the "WP3 – Validation and Platform Integration", was related to the infrastructure TERRASCOPE. The SARSAR processing chain was first implemented in the standard environment offered by TERRASCOPE. But during the testing phases it was realized that more resources were needed: to handle the large volume of data we finally had to use a more advanced database system, which was promptly provided by VITO. It consists of a multithread geodatabase (PostGIS) running on a multicore CPU with 24 Gb RAM and a large amount of drive space disk (>15 To).

Another problem encountered, linked to the WP3, was that the number of Pléiades received was less than expected and the image quality was poor. The Pléiades were used for validation purposes, as they offer better spatial resolution than Sentinel images, and better temporal resolution than orthophotos. The image below illustrates the problem for Charleroi area, 4 images instead of 9 were received for the first months of 2019 when 1 image per month was requested:



Two different solutions have been put in place. The first was to ask Airbus to raise our priority. Thanks to that solution, 11 images of rather good quality have been received for Charleroi in 2020. The second solution was to order Pléiades archives. We received 3 images for Charleroi and 6 for Liège. Unfortunately, several images were only a few days apart, and moreover the interval between months/years was too long and disparate to use these images as ground truth. Since the images were dated from mid-2016 to February 2018, it was decided to focus only on the ground truth based on the orthophotos for that time period.

The last problem is related to the "WP2 – Dynamic Monitoring of Redevelopment Sites". If, on the one hand, the use of the RDSs vector polygons in the change analysis to group the corresponding image pixels and average the information over the whole site has the twofold advantage of limiting the effect of noise and reducing the overall processing time, on the other hand, it brings some limitations. In particular, for large sites, this might lead to the non-detection of small changes, as shown in the figure below.

Orthophoto 2019 Orthophoto 2020

To address the problem, we performed several tests by applying different types of segmentation based on either a fixed grid or external sources. However, although this allowed us to detect some finer details, it led to a general increase of false alarms. According to the results of our performance assessment, the trade-off between correct detections, false alarms and missed detections, was in favour of the full-site processing, therefore we ultimately opted for that solution.

3.4 LESSONS LEARNED

This project was an excellent opportunity to improve our scientific skills in change detection and qualification. It has shown us that combining SAR and optical data can add significant value to meet application needs. But it also showed us that, due to the Sentinel data's spatial resolution, choices had to be made regarding the surface area of the redevelopment sites knowing that they were sometimes too small to be able to validate the change detection.

The project also allowed us to increase our technical skills in process automation with all its difficulties (see section 3.3 "Problems Encountered and Solutions").

Finally, we have also learned that for application projects, users need results that are straightforward to understand, interpret and use. This has highlighted the difference between these needs and the scientific developments which are often much more nuanced and complex. It has led us to better understand the gap between the end users and the scientific community, to adapt and to make the link between the two.

3.5 ASSESSMENT OF PROJECT AND PROJECT ACHIEVEMENTS BY COORDINATOR (NON-SCIENTIFIC PARTNER)

For the coordinator, as a user of the project results, the understanding of the satellite data processing tools was more complex than initially expected. The same was true for the role played by the TERRASCOPE platform, as well as its interest. The partners of the SARSAR project were able to answer the different questions that DAOV had about these tools, and thus improve the comprehension of them.

Regarding the project results, the validation shows that their accuracy is satisfactory in order to support the redevelopment sites management, although it is slightly lower for small or very large sites (less than 500 m² or more than 10,000 m², the first being due to the minimum size per polygon to cope with the spatial resolution of Sentinel data and the second being due to the proportionally smaller size of the changes on the very large sites). Thanks to these results, and thanks to their complementarity with those from the “SAR” project (visual analysis of the redevelopment sites, by photo-interpretation, of the orthophotos), DAOV is able to significantly improve the daily work to be done for the maintenance of the RDS inventory and its update.

In the next few months, DAOV will be able to practically use the SARSAR results, both those related to "date" and "summer" changes, and feedback will be provided to ISSeP and RMA for potential further improvements.

3.6 USE OF BELGIAN RS INFRASTRUCTURE AND INSTRUMENTS

For the purposes of the project, we used the TERRASCOPE platform. TERRASCOPE is a Belgian platform managed by VITO in the framework of the Belgian contribution to the Copernicus Ground Segment. More specifically, we used the access to the pre-processed and updated S1 and S2 satellite data archives, their virtual machine and their Jupyter Lab. In addition to the TERRASCOPE tools, we used a CentOS Linux server provided by VITO for our PostGIS.

3.7 UPTAKE OF RS BY NEW USERS

The adoption of remote sensing by DAOV/SPW has been underway for several years, but more specifically through the use and analysis of annual orthophoto campaigns. The interest of remote sensing has been clearly put forward and demonstrated by several prototypes. For almost 3 years, orthophoto analysis campaigns have been used and integrated in the process of updating the SAR/Brownfield database and in the management of field validation campaigns.

Satellite remote sensing and in particular Sentinel 1 and 2 images are still only used through the process set up by the SARSAR project. In this case, as explained in this report, it is an indirect use through automated reporting. However, following the analysis of the needs, but also of the internal competences, it turns out that this is the best solution for an administration like DAOV/SPW to benefit from the advantages of satellite data.

On the other hand, the good collaboration and long-term missions that link the ISSeP and the DAO/SPW will allow the tool to be updated and improved according to the feedback from its day-to-day use and according to the feedback from the field teams.

4 PERSPECTIVES FOR FUTURE RESEARCH

In terms of perspectives, several avenues are possible/envisaged

At the level of the application itself:

- Making the methodology transferable to other regions in Belgium;
- Testing the application to other European brownfields.

At the level of reuse/modification of the application:

- Test change detection on specific sites such as airports, ports, logistics sites etc...;
- Inventories management for land use strategies;
- Local land management, urban planning, site reconversion ...;
- Agricultural and forestry areas monitoring, e.g. differentiation between temporary and permanent grasslands, for climate reporting;
- Disaster response mapping such as flood, landslide or earthquake zones.

At data level:

- Depending on other available data, like orthophotos or Pléiades if available from budget point of view (see section 5.2). But in this case may need other support than TERRASCOPE, as only Sentinel data are currently available;
- Use of hyperspectral data (Prisma?).

At technical level:

- Methodology transfer to other platforms or internally, allowing access to other types of data

5 STEERING COMMITTEE

5.1 REPORT OF THE LAST STEERING COMMITTEE

GENERAL COMMENTS:

The Steering Committee is favourably impressed by the project.

A lot of work has been done since the last meeting, despite the ongoing Corona crisis. Because of time constraints, a lot of work had to be compressed in short presentations which did not allow for too much detail. However, the Q&A sessions revealed that the methodological choices made were justified in a scientifically sound manner. This is to be commended as this work started from scratch and there was no existing external methodological framework to build upon.

While there is scope for improvement, in particular as concerns the classification/change detection of buildings, the developed methodology appears robust and well-supported.

The resulting tools will not only be useful for the Walloon administration for also for a large scientific community and for other types of applications, e.g. monitoring of long-term land-cover changes as a result of a changing climate, in disaster response mapping or environmental risk assessments. Therefore, additional dissemination activities are warranted (see below).

The project is clearly on its way to achieve its objectives and the members of the Steering Committee would like to be kept informed and receive the full results at the end of the project.

RECOMMENDATIONS:

CHANGE DETECTION

- Improving the classification and detection change of buildings should now be a priority.
- Future work might look further into:
    - using other RS data sources with a higher spatial resolution such as Pléiades;
    - using machine learning to set change thresholds;
    - pixel-based change detection and segmentation.

IMPLEMENTATION

The Steering Committee would like to have more details about the proposed implementation: response time; user-friendliness; ...

DISSEMINATION AND VALORISATION

The team is encouraged to:

- not only publish the results in conference proceedings, but also in a high impact journal;
- to continue the work in follow-up projects wherever possible.

The members of the Steering Committee may help to validate the results over other geographical areas.

5.2 FEEDBACK TO STEERING COMMITTEE

CHANGE DETECTION

- The last three months of the project will be devoted to finalizing the system and improving both the change detection and the change classification, with a particular focus on increasing the accuracy for the buildings class. Investigation will be carried out to reduce the number of FPs/FNs and to fine-tune the change thresholds. Research on a combined building/soil classification will be conducted to determine the relationship between building and soil change, as we noticed both are often linked. Finally, the use of Sentinel-1 in combination with Sentinel-2 will be investigated.

- Despite their limited spatial resolution, using Sentinel data for change detection has three main advantages: they offer a high temporal resolution, they are available for free and can guarantee a long-term coverage. If, on the one hand, Pléiades images, which we have used in WP3 for validation, have a better spatial resolution and would be extremely useful for the goal of this project, on the other hand, they have one important drawback: their price. At the current rates, a single-date full coverage of Wallonia would have a cost of roughly 50.000€, which make them not suitable for time series. Investigations will be done on the possibility of using other remote sensing sources keeping in mind this is an operational project. Finally, a scientific watch will be carried out in order to follow the evolutions in the new satellites.

- Machine learning methods have been initially considered but ultimately dismissed as we were confronted with the limited number of samples. In fact, according to the SAR project, which was based on the visual analysis of orthophotos taken between 2012 and 2018, around 10% of the RDSs are likely to change each year, all types of changes included. However, our interest in AI techniques remains and we will investigate the potential for SARSAR.
  Moreover, ISSeP has just started a new project called “INTELLO” (Intégrer l’INTElligence artificielle dans les outils de suivi de l’environnement WalLOn) which is investigating how artificial intelligence could improve the tools for monitoring the Walloon environment. One of the objectives of the project is to explore how AI could contribute to change detection for the RDSs monitoring and could provide us with useful insights.

- According to the tests conducted so far, for small and medium-sized sites the best approach is to focus on the full site. Instead, for very large sites, we definitely agree that an approach taking into account segmentation will likely improve our capability of detecting changes. We are currently running a new test using segmentation where the RDSs have been divided into smaller polygons of about 10Km2.
  As regards the pixel based approach, as we mentioned during the meeting, we had to face some computation limitations. However, we are working in close contact with VITO, who is managing TERRASCOPE, in order to find the most adequate technical improvements. For example, a couple of weeks ago we have been provided with a dedicated machine that will allow us to speed up the processing times. If need be, we will consider to apply pixel-based segmentation to specific sites that require a particular level of detail.

IMPLEMENTATION

- Regarding the user-friendliness, the tool will completely run automatically on TERRASCOPE at scheduled dates and send the results by mail to the final user (Walloon Region-DAOV). In this way, the final user does not have to worry about the tool management. A Jupyter notebook, along with the relevant technical documentation, will be available for cases when the end user would like to manually launch some specific modules of the tool, for instance when additional time steps that have not initially been scheduled are needed.

- Regarding the processing time, we have to separately consider the three components of the method. As far as the creation of the temporal profiles is concerned, we cannot yet provide a specific number, as the "postGIS method" is still under development. Indeed, we recently got access to a dedicated high performance server thanks to our continuous interactions with the TERRASCOPE technical team. Compared to the “sqlite” method running on a standard virtual machine, we are moving from 8GB RAM to 24GB RAM, from single-thread (due to sqlite limitations) to multithread thanks to PostGIS and 6-core hyperthreading enabled CPU. So, what we can already say is that the execution time will be much shorter than the “sqlite” method. For reference, it took around 4 weeks to process the results on all the sites for all the Sentinel images since 2015. As far as the change detection is concerned, depending on the length of the time series and the number of features, the processing time ranges from a few minutes to a few hours. Finally, the change classification takes a couple of hours. In conclusion, considering that once the service is operational only a few new sites per year will have to be processed from scratch, the processing time would definitely be able to produce results every two months as mentioned in the user's needs (WP1).

DISSEMINATION AND VALORISATION

- Since the preliminary results based on the analysis of the 22 test sites will be presented at IGARSS2021, the natural follow-up is the publication of the detailed methodology description and full performance assessment in the IEEE J-STARS special issue that is usually proposed a few months after the conference. If for any reasons this year the organizers are not posting a call for papers, another peer-review journal will be chosen.

- The project has also been presented at EARSeL Liège 2021. There is no special issue directly linked to the joint workshop foreseen, but we are strongly encouraged to submit a full paper in the EuJRS (European Journal of Remote Sensing), which we will definitely do.

- The SARSAR change detection tool will become operational and maintained/updated also after the end of the project. Depending on the availability of new funds, it would be certainly interesting to further develop the methodology and introduce new features.

6 DESSIMINATION ACTIVITIES

The part of the dissemination activities related to the process automation will be incorporated in the Dissemination and Support project TERRA2SAR (see section 7).

Indeed, in this project it is planned to improve the codes created in the framework of the SARSAR project in order to produce operational Jupyter Notebooks that can be transposed to other fields of application. The TERRASCOPE Jupyter notebooks, based on the standard as well as on the upgraded TERRASCOPE configurations, will be published. The methodologies will also be published in a paper as this will explain in more details the steps and the choices made in the framework of the SARSAR project. Test data will be made available with the different source code (Jypyter Notebook) on specific exchange plateform like GitHub or TERRASCOPE website in accordance with VITO.

6.1 SCIENTIFIC PAPERS

PUBLISHED[7]

M. Stasolla, S. Petit, C. Wyard, G. Swinnen, X. Neyt and E. Hallot, "Urban Sites Change Detection by Means of Sentinel-1 and Sentinel-2 Time Series," 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021, pp. 1065-1068, doi: 10.1109/IGARSS47720.2021.9555060.

The follow-up journal paper showing both change detection and classification results is in preparation: see section below.

SUBMITTED

IN PREPARATION

Sophie Petit, Mattia Stasolla, Coraline Wyard, Gérard Swinnen, Xavier Neyt and Eric Hallot, “Sentinel-1 and Sentinel-2 Time Series for Near Real-Time Automatic Monitoring of Redevelopment Sites in Wallonia, Belgium”, TBD (probably either in Land, Special Issue entitled "Land Surface Monitoring Based on Satellite Imagery, or in Journal of Applied Remote Sensing)

6.2 POSTERS

6.3 SOFTWARE

N/A

6.4 DATA ACCESS[8]

[7] Full bibliographic reference, including doi – separate conference papers
[8] Give to link of data repository where project data can be accessed by the community.

The data will be made available in the framework of the TERRA2SAR project, as they will be generalized so that they can be transposed to other fields of application.

6.5 IMPLEMENTATION OF PROJECT RESULTS WITHIN ORGANISATION OF COORDINATOR[9]

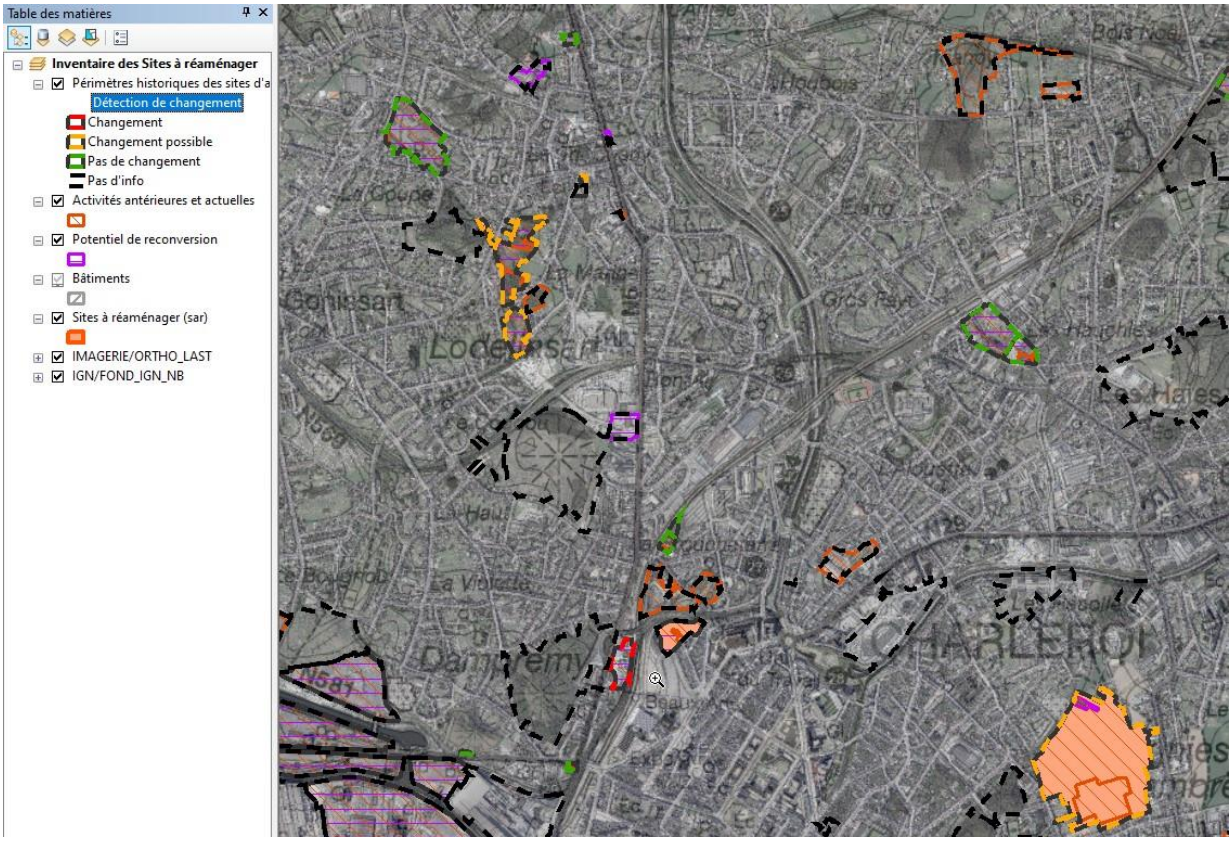
Since 2018, ISSeP has conducted the SAR project, in collaboration with DAOV. This project consists of providing support for the update of the RDS inventory by using a photo-interpretation methodology. In 2018, the orthophotos from the 2012/13, 2015 and 2016 campaigns were analysed, followed in 2019 by the 2018 campaign. During these analyses the sites were examined in a random order.

As of this year and the analysis of the 2020 orthophotos, currently being finalized, the first SARSAR results could be integrated in order to prioritize the sites to be investigated by photo-interpretation. Therefore, the results of the SAR project are now being provided to DAOV as the visual analysis proceeds and, the sites presenting the most changes were able to be treated in priority by DAOV field team. For the next campaign, the final results of the project will be integrated to further optimize the analysis by orthophotos. This will allow the field teams to continue to improve the planning of their field visits.

Depending on the final developments necessary to fully automate the processes, but also on the first feedback from the DAO, it is expected that the service will be operational in the first quarter of 2022. From then on, since SARSAR results will be provided every two months in addition to once a year with the orthophotos analysis, they will also be used by the different SAR managers. Indeed, the latter are each responsible for monitoring a selection of SARs, and must regularly be informed of the evolution of each of the sites they are responsible for. The results of SARSAR will allow them to optimize their work management and to provide regular and updated feedback to the different actors with whom they work.

Finally, the simplified results will also be displayed on an internal DAOV cartography allowing all the stakeholders to visualize in near real time the status of each SAR, i.e. whether it presents a high medium or low probability of change. The following image shows the project for the online visualization.

[9] Both done and planned



Concerning the improvements and modifications of the tool, part of the monitoring of the SAR sites and the updating of the database is provided by a grant from the Walloon government to the ISSeP. As explained during the project, it is thanks to this grant that ISSeP will be able to monitor the SARSAR application and that it can be updated according to the evolution of the management policies of the DAO or the Walloon government.

6.6 OTHER TYPES OF OUTREACH

SOCIAL MEDIA

PRESS

LE VIF - NUMÉRO 07 - 18.02.2021 (Source of the article content: http://lampspw.wallonie.be/dgo4/site_sar/index.php/presentation/index)

POPULARISATION ACTIVITIES

https://terrascope.be/en/cases/automatic-redevelopment-sites-monitoring-using-sentinel-data

https://terrascope.be/en/news-events/register-our-new-terrascope-webinars

OTHER (AWARDS, GUEST LECTURES, …)

- Stasolla Mattia, "Exploiting the Copernicus Sentinels for the Automatic Monitoring of Redevelopment Sites", presentation at the CISS Lecture Series 2020, Royal Military Academy, Feb 2020, Brussels, Belgium.
- Petit Sophie, "Exploitation des données de télédétection (Optiques et Radar) pour la surveillance automatique de sites d'intérêts. Cas des Sites À Réaménager (SAR)", presentation at the GT-COWal, Nov 2019, Namur, Belgium.
- Petit Sophie, "The potential of SAR and OPTICAL Sentinel images for the automatic monitoring of redevelopment sites", presentation at the BEODAY, Nov 2019, Kluisbergen, Belgium.
- Petit Sophie, "Sentinel data supports automatic monitoring of redevelopment sites!", TERRASCOPE webinar, Oct 2021, online.

Like planned in the WP5 (Annexe I) a user workshop for the Walloon Region will be scheduled. It will take place in 2022 and will be held in a GT-COWal, following the one held in November 2019.

6.7 COLLABORATION WITH OTHER BELSPO PROJECTS

7 NEW PROJECTS AND INTERNATIONAL COLLABORATIONS STARTED (PARTLY) BASED ON RESULTS OF THIS PROJECT

The outcomes of SARSAR have resulted in a methodology, developed in TERRASCOPE platform, for the automatic monitoring of land-cover changes at a selection of sites of different sizes spread over a large area. As such an application could be useful to a larger scientific community and for other types of applications, a BELSPO Dissemination and Support project has been submitted by ISSeP and was accepted. The TERRA2SAR project "TERRASCOPE for Sentinel-1 and Sentinel-2 time-series automatic analysis" will focus on several tasks:

- The improvement of the codes in order to produce operational Jupyter Notebooks that can be transposed to other fields of application. This task will be separated into two parts:
  - Python Jupyter Notebook compatible with the standard TERRASCOPE virtual machines configuration;
  - Python Jupyter Notebook based on an upgraded TERRASCOPE configuration;
- The publication of the methodologies in a paper;
- Establish the basis for a double validation of the SARSAR project results.

This is a 6 months project has started in October 2021

In addition to the TERRA2SAR project, ISSeP is currently investigating how parts of the SARSAR processing chain can be used for other applications. Several avenues are being explored:

- an ESA-funded project "Space-based services for Smart Airports" in collaboration with the company Oscars s.a.
- a monitoring module to differentiate between temporary and perennial grasslands in the context of EO4LULUCF reporting in collaboration with AWAC
- the feasibility of transposing certain processing chains to other types of platforms (such as spatial Oracle or other CGS).

On the ERM side, part of the results of this project will be used in project DAP21-04, which is funded by the Royal Higher Insitute for Defense and whose goal is the AI-assisted analysis of satellite images.

Following the SC meeting discussion, a collaboration between RMA and the University of Pavia has started where a student at the University of Pavia has worked for his master's thesis on the change detection of urban sites in Northern Italy based on the change detection routine developed at RMA.

Also, Dr. Stasolla has been invited for a short teaching period at the University of Pavia in 2022.

8 COPY OF PUBLISHED PAPERS

https://doi.org/10.1109/IGARSS47720.2021.9555060

9 ADDITIONAL INFORMATION[10]

Additional information can be found in different reports of the deliverables, available at this location: https://sarsar.issep.be/

Some of the documents are in French as they are intended for the final user, DAOV, for direct use.

- D0.2: Activity report (midterm report) “SARSAR_activity-report.pdf”
- D1.1: User Requirements Document “SARSAR_WP1_UsersNeeds.pdf”
- D3.1: Performance assessment report “SARSAR_WP3_D3.1_PerformanceAssessment.pdf”
- D4.1: User manual “SARSAR_WP4_UserManual.pdf”

Given that the coordinator and user of the project results is the Walloon Public Service (Direction de l'Aménagement opérationnel et de la Ville - DAOV), the documents directly intended for the latter have been written in French (D1.1 & D4.1).

In addition, to the reports links to the deliverables, several documents are also available:

- Presentations to the Steering Committee:
  - “SARSAR_20190926_Intro_final.pdf”
  - “SARSAR_20190926_WP1_UsersNeeds_final.pdf”

[10] Detailed description methodology, statistics, reports, …

- "SARSAR_20190926_WP2_final.pdf"
- "SARSAR_20210319_SC_final.pdf"

10 PROJECT ILLUSTRATIVE MATERIAL[11]

https://wetransfer.com/downloads/71589ce99c38e322d9f5cf6106c8b6c920211130144952/02fed3f04d7882d147cf032b4903c94920211130145012/6c3019

Also available in "SARSAR_webstory"

11 PROJECT SHEET (separate form)[12]

12 PROJECT WEBSTORY (separate form) [13] [14]

[11] In attachment by Wetransfer or ftp link; high resolution photographs of field campaigns, graphs and maps. You may also provide us with pictures of the team members if so wished. By sending us photographs, you agree that BELSPO can use them for its websites and other forms of communication.

[12] Form available on project management website

[13] Form available on project management website

[14] Story for broader audience on interesting aspect of project, e.g. fieldcampaign, cross border cooperation