# SARSAR – SR/00/372

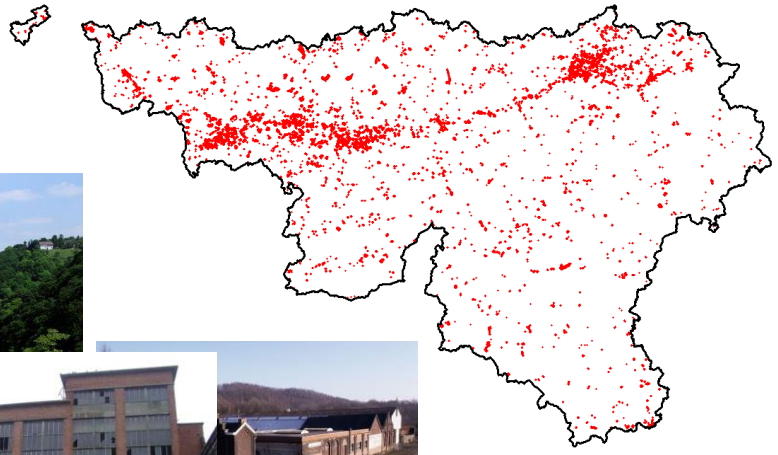
## Automatic redevelopment sites monitoring using SAR and OPTICAL images

### Introduction

Steering Committee Meeting - 19th March 2021

# Introduction

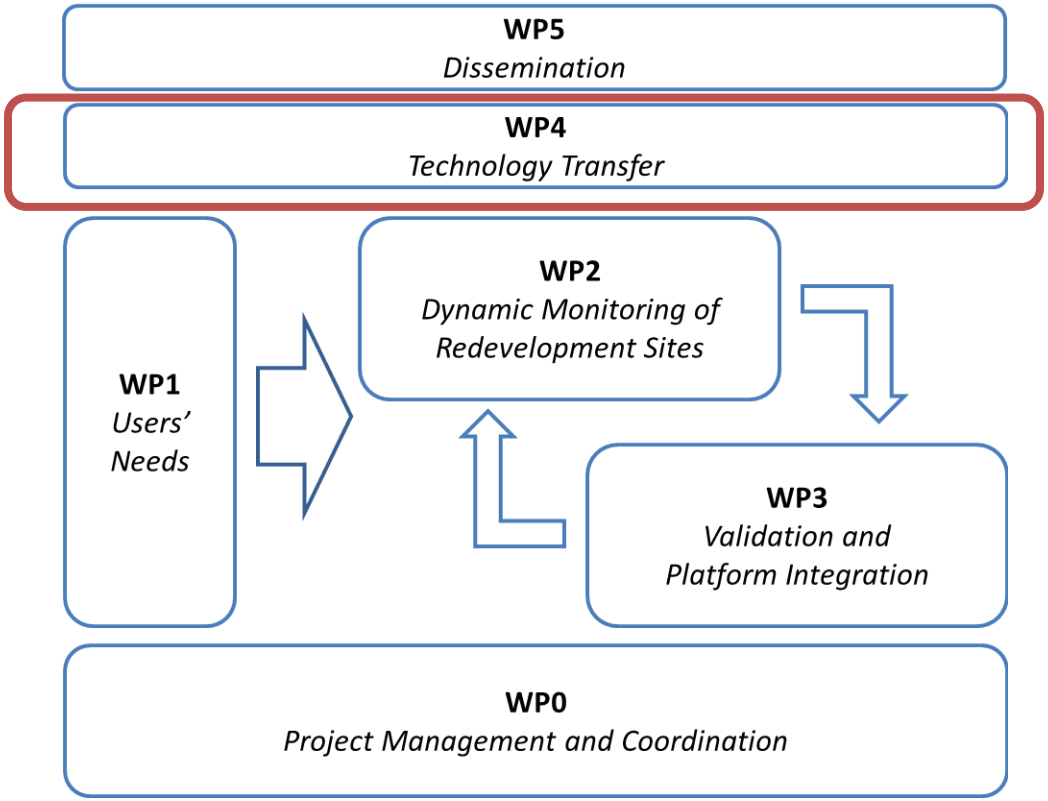
2,200+RDSs over
3800ha in Wallonia



- Project goals
  - Contribute to the RDSs inventory update
    - Reduce and optimize the time spent on the inventory update
    - Provide up-to-date and accurate information to the actors involved, especially for those who access the online version

→ Need for an automatic tool

# Work Packages




| Work package | YEAR 1 | YEAR 2 |
|---|---|---|
| WP 0: | | |
| WP 1: | | |
| WP 2: | | |
| WP 3: | | |
| WP 4: | | |
| WP 5: | | |

# WP1 – Users' Needs: summary

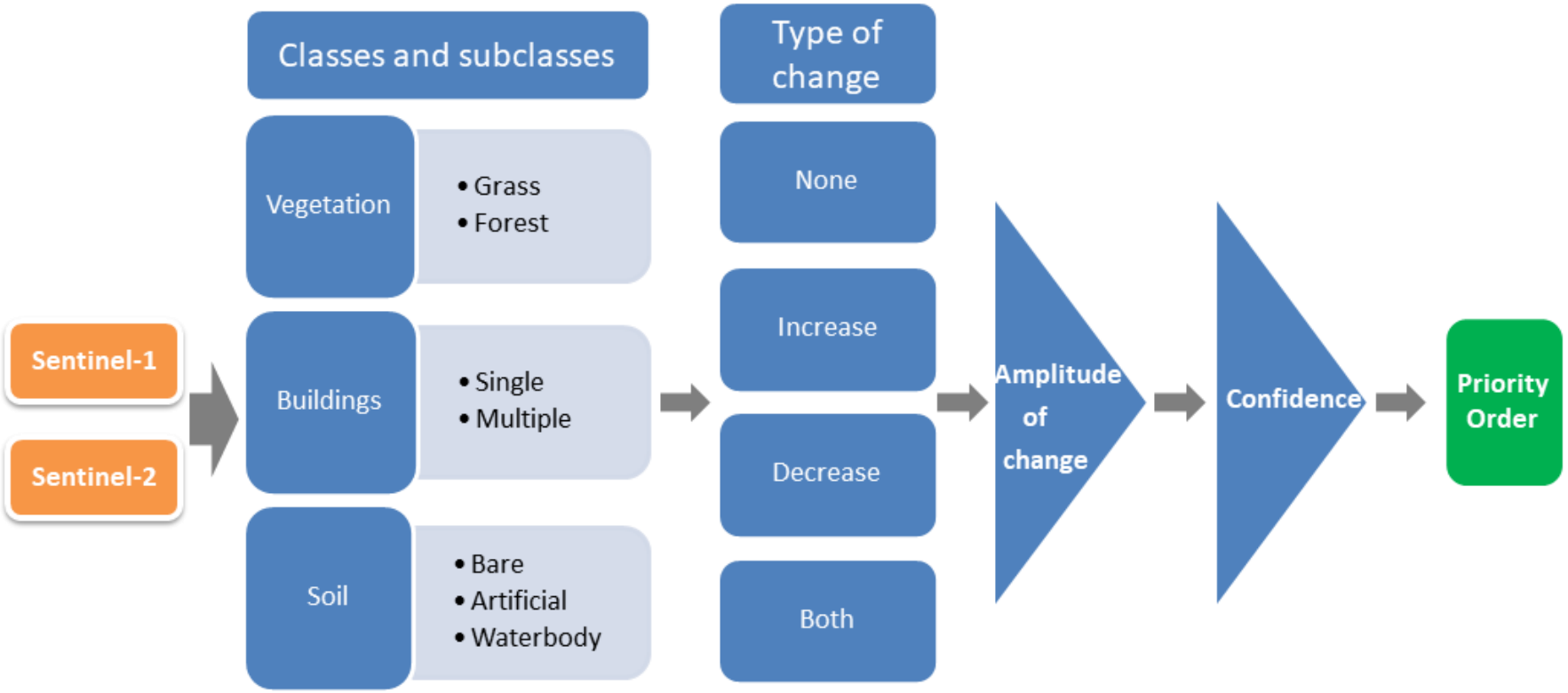
- Users' needs
  - Lower costs by limiting the number of sites to be verified in person
  - Automate, as much as possible, change detection
  - Facilitate the work of the operators by pre-identifying the elements to check
  - Decrease the subjectivity of the operator

# WP1 – Users' Needs: summary

- Answers to the needs
  - Must have:
    List of the sites with their probability of change
  - Nice to have:
    Change confidence score for each site based on a selection of pre-established scenarios (categories and types of changes). Importance of taking into account specific situations where no long-term change may mean that the site is maintained (e.g. pasture/meadow)

# WP1 – Users' Needs: summary

- Categories and types of change



# WP1 – Users' needs and requirements

- Summary of the proposed solutions

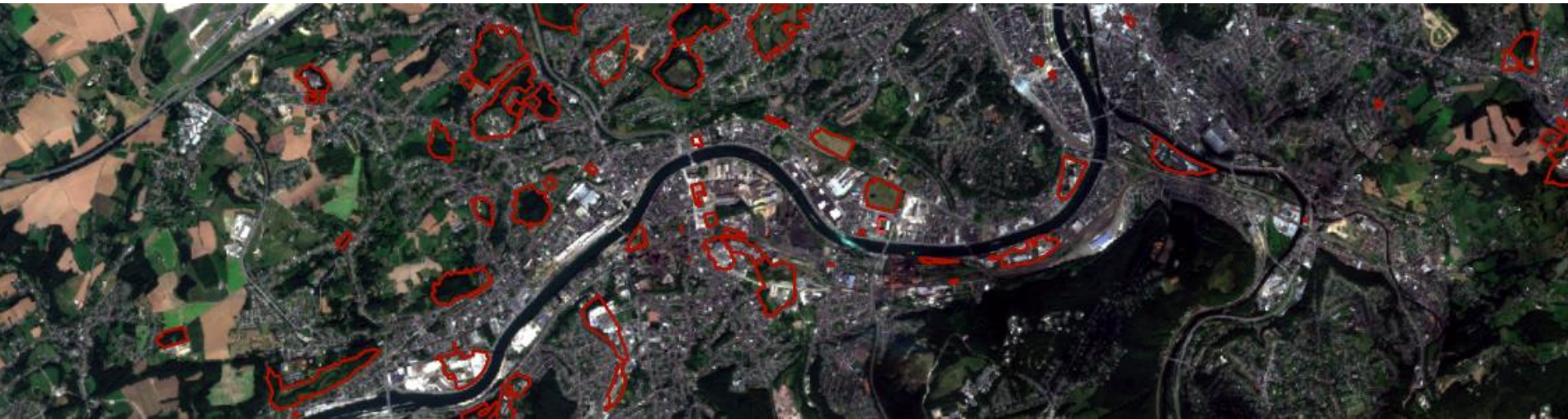
| Requirements | | Proposed solutions |
|---|---|---|
| Deadlines | | • 1X/year<br>• On demand<br>• Nice to have: 1X/2months |
| Tool | Method | • Python Scripts<br>• Terrascope Interface<br>• Results sent via email |
| | Format | • CSV or TXT files with ID & Priority order<br>• More details on demand<br>• Nice to have: WFS<br>• Nice to have: alert system on the RDSs website |

# SARSAR – SR/00/372

## Automatic redevelopment sites monitoring using SAR and OPTICAL images

**WP2 – Dynamic Monitoring of Redevelopment Sites**
**WP3 – Validation and Platform Integration**

Steering Committee Meeting - 19th March 2021



# Overview

1. Methodology
2. Feature extraction
3. Changepoint detection
4. Change Classification
5. Platform integration

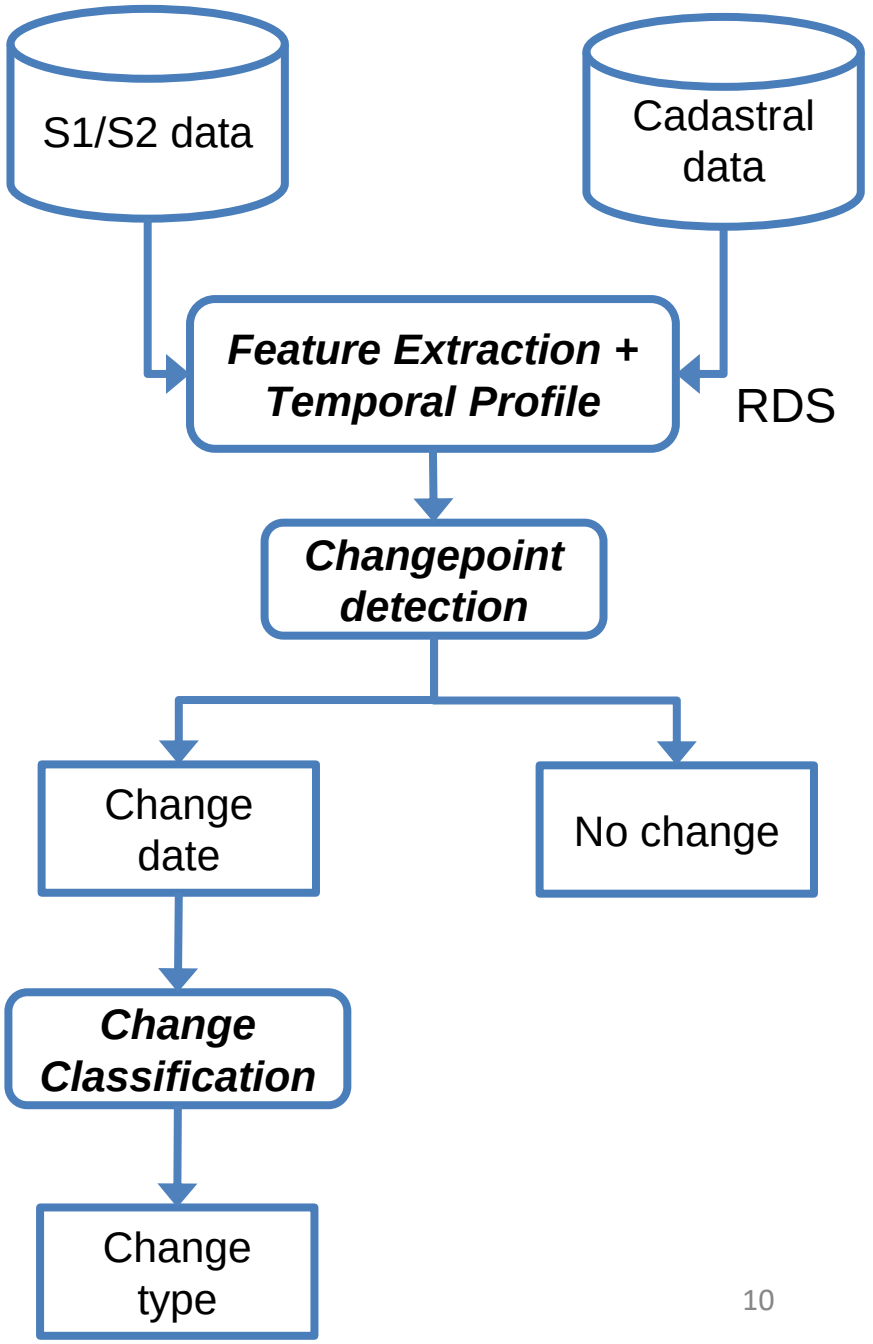
# 1. Methodology

- Input:
  - S1 (Sigma0)/S2 (ToC) from Terrascope Catalogue
  - Shapefile of the RDS

a) Feature extraction + Generation of temporal profiles

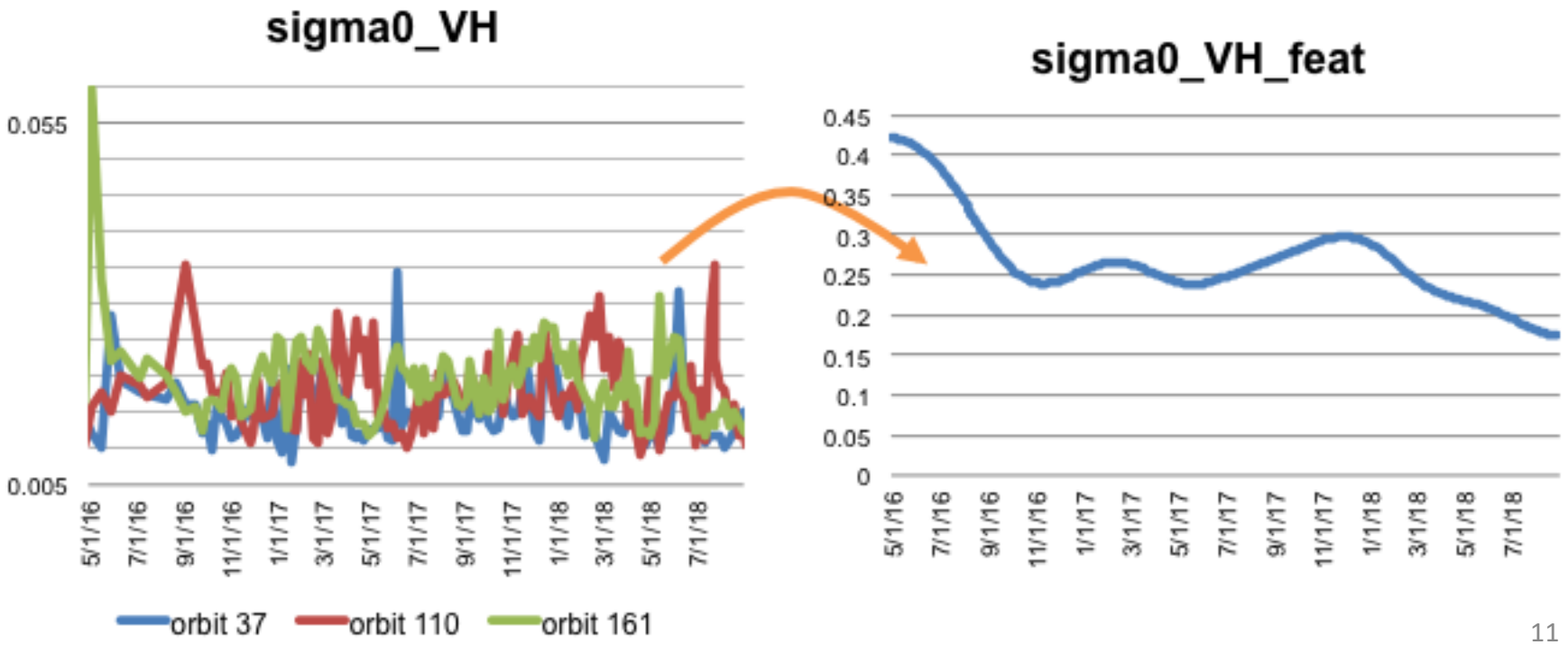
b) Changepoint detection

c) Change classification



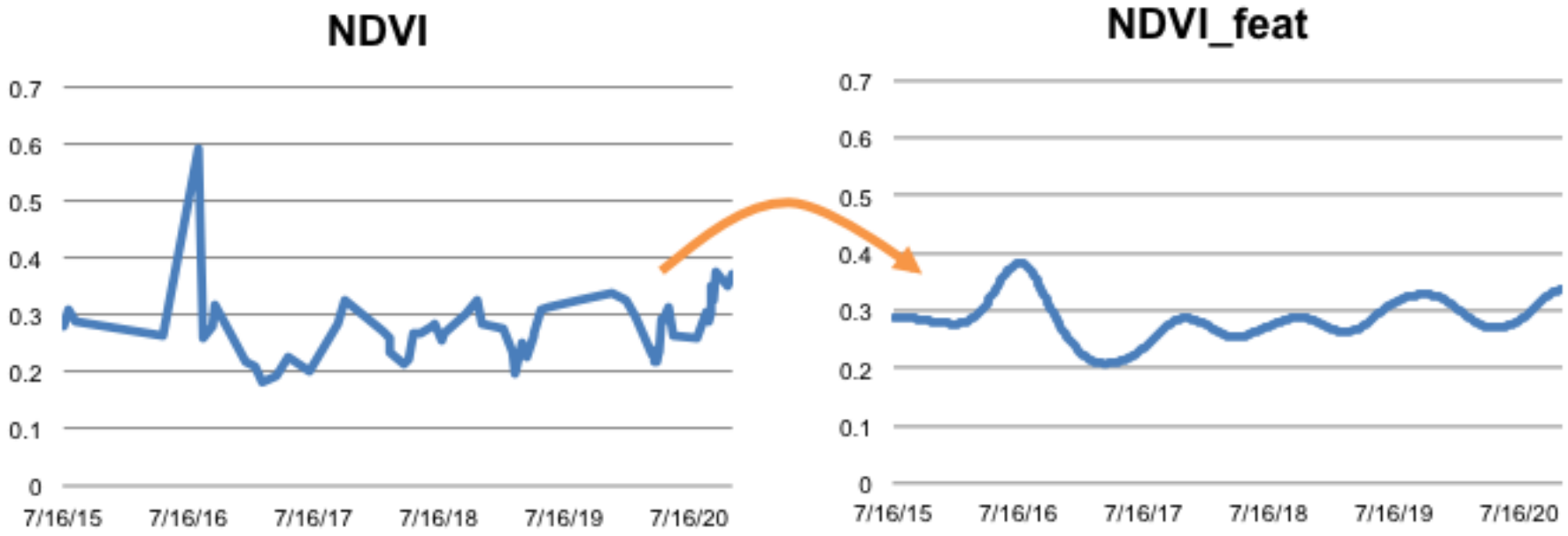
# 2. Feature extraction – Sentinel-1

- Sentinel-1 time series
  - IW GRD → sigma0
  - Interpolation
  - Gaussian smoothing
  - All available orbits → average



# 2. Feature extraction – Sentinel-2

- Sentinel-2 time series
  - L1C → iCor/Sen2Cor → L2A
  - Tile Cloud cover < 25%
  - RDS Cloud/shadow/snow = 0% (scene classification)
  - Interpolation
  - Gaussian smoothing
  - 13 Multi-spectral indexes (NDVI, SAVI, NDWI, NDWI2, NDBI, NBAI, NBI, BAI, BI, BI2, CI, BSI & SBI)



# 3. Changepoint detection

- Pruned Exact Linear Time (PELT) method [1]
  - It provides an exact segmentation of the time series with a linear time complexity.

Given a time series $s = (s_1,\ldots,s_k)$, the number n and time position $t_{1:n} = (t_1,\ldots,t_n)$ of the changepoints is obtained by solving the penalized minimization problem

$$Q_n(s_{1:k}, p) = \min_{n, t_{1:n}} \left\{ \sum_{i=1}^{n+1} [C(s_{(t_{i-1}+1):t_i})] + p \right\}$$

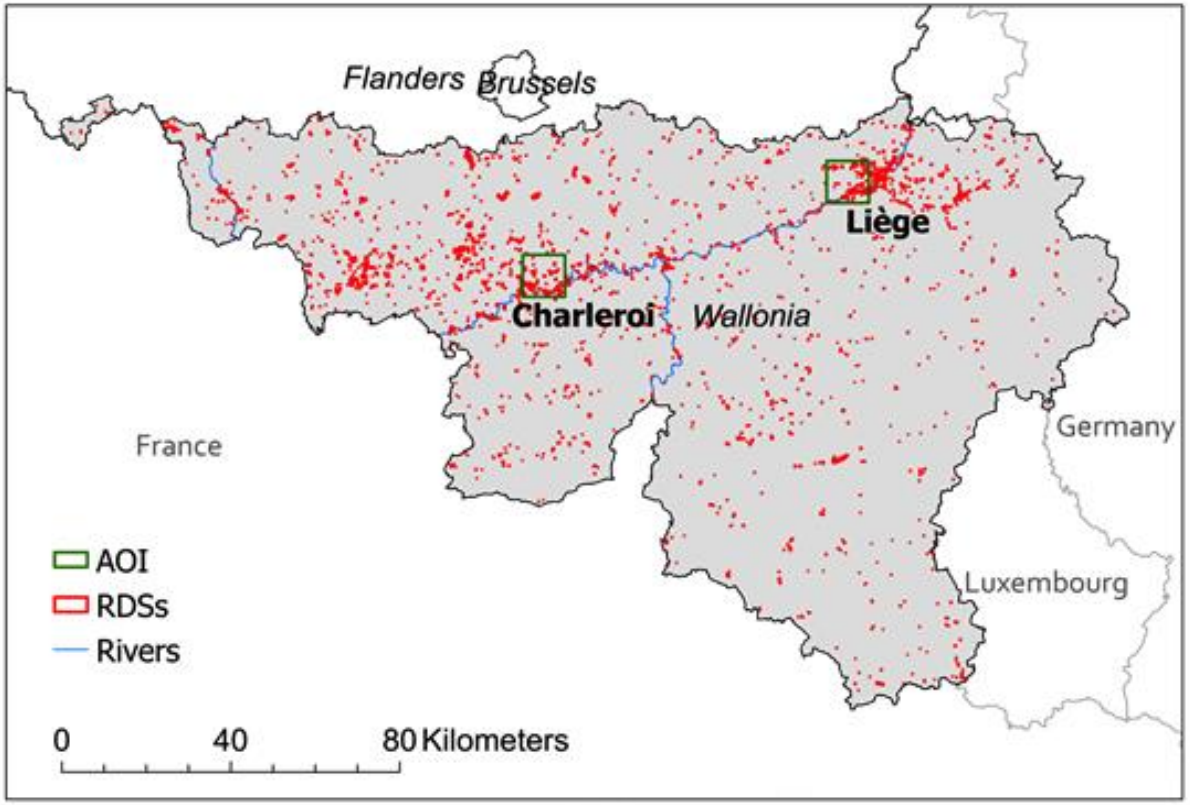
where $C$ is a segment-specific cost function, and $p$ a penalty term to control overfitting. For our analysis we have used

$$C(s_{a:b}) = \sum_{i=a+1}^{b} \left\| s_i - \overline{s}_{a:b} \right\|_2^2$$ suitable for mean-shifts and $p=\log(k)$

[1] R. Killick, P. Fearnhead, and I. Eckley, "Optimal detection of changepoints with a linear computational cost", *Journal of the American Statistical Association*, 107(500):1590–1598, 2012

# 3. Validation strategy

- Two phases:
  - Development based on 22 sites within the urban areas of Charleroi and Liège (green squares)
    - Feature selection
    - Change detection
    - Types of change
  - Extensive tests on the full dataset (2291 RDS, red marks)



# 3. Change detection – Phase 1 (22 sites)

- Ground truth
  - year-on-year changes in vegetation, buildings and soil
    - 0 = no change
    - 1 = change (same surface)
    - 2 = increase
    - 3 = decrease

→ 31 changes, 57 no changes

| ID_Segment | NAME | Orthophotos | | | Pleiades | Change |
|---|---|---|---|---|---|---|
| | | 2016-2017 | 2017-2018 | 2018-2019 | 2019-202( | |
| 52011-ISA-0015-01 | Administration Cockerill | 000 | 000 | 000 | 000 | 0\|0\|0\|0 |
| 52011-ISA-0032-01 | Cinema-Theatre Varia | 000 | 000 | 000 | 000 | 0\|0\|0\|0 |
| 52011-ISA-0040-01 | Cordial Bowling | 000 | 203 | 000 | 302 | 0\|1\|0\|1 |
| 52012-ISA-0011-01 | Hangars Vanbelle | 332 | 001 | 023 | 000 | 1\|1\|1\|0 |
| 52012-ISA-0017-01 | Charbonnage n10 du Gouffre | 000 | 000 | 000 | 000 | 0\|0\|0\|0 |
| 52021-ISA-0007-01 | Cha | | | | 000 | 0\|0\|0\|0 |
| 52021-ISA-0008-01 | Cha | | | | 000 | 0\|0\|0\|0 |
| 62003-ISA-0004-01 | Ets | | | | 001 | 0\|0\|0\|1 |
| 62063-ISA-0034-01 | Ren | | | | 000 | 0\|1\|0\|0 |
| 62063-ISA-0037-01 | Par | | | | 000 | 0\|1\|1\|0 |
| 62063-ISA-0098-01 | Bol | | | | 000 | 1\|0\|0\|0 |
| 62063-ISA-0181-01 | Cer | | | | 000 | 0\|0\|0\|0 |
| 62063-ISA-0189-01 | Cig | | | | 000 | 0\|0\|0\|0 |
| 62063-ISA-0201-01 | Bat | | | | 000 | 0\|0\|0\|0 |
| 62063-ISA-0230-01 | Ma | | | | 320 | 0\|1\|1\|1 |
| 62063-ISA-0247-01 | Ser | | | | 000 | 0\|1\|1\|0 |
| 62093-ISA-0026-01 | Puits de mine - rue Renson | 000 | 000 | 000 | 000 | 0\|0\|0\|0 |
| 62096-ISA-0038-01 | Verreries Liegeoises | 000 | 203 | 000 | 302 | 0\|1\|0\|1 |
| 62096-ISA-0039-01 | Ets Linotte | 332 | 203 | 203 | 203 | 1\|1\|1\|1 |
| 62096-ISA-0052-01 | Haut Fourneau 6 | 302 | 203 | 000 | 332 | 1\|1\|0\|1 |
| 62096-ISA-0056-01 | Maison des Espagnols | 332 | 203 | 000 | 332 | 1\|1\|0\|1 |
| 62118-ISA-0002-01 | Ets Frankignoul | 323 | 203 | 101 | 001 | 1\|1\|1\|1 |

| Year | Building | Vegetation | Soil | Aggregate |
|---|---|---|---|---|
| **2016/2017** | 5 | 6 | 7 | **7** |
| **2017/2018** | 3 | 8 | 11 | **11** |
| **2018/2019** | 2 | 4 | 5 | **6** |
| **2019/2020** | 2 | 5 | 6 | **7** |
| **2016-2020** | 12 | 23 | 29 | **31** |

# 3. Change detection – Phase 1 (22 sites)

- Performance assessment:
  - tried around 200 combinations (different features, smoothing, segmentation)

- Findings:
  - smoothing is necessary to avoid overfitting
  - at least one Sentinel-1 feature (buildings) and one Sentinel-2 feature (vegetation/soil)
  - more than 4 features → overfitting
  - segmentation does not bring significant improvement (further tests on the full dataset needed)

# 3. Change detection – Phase 1 (22 sites)

- Results (features: sigma0, NDVI)

Sigma0_VH_feat

| Year | TP | FP | FN | TN | TPR | FPR | $F_1$-score |
|---|---|---|---|---|---|---|---|
| **2016/2017** | 3 | 1 | 4 | 14 | 43% | 7% | 0.55 |
| **2017/2018** | 1 | 1 | 10 | 10 | 9% | 9% | 0.15 |
| **2018/2019** | 0 | 0 | 6 | 16 | 0% | 0% | 0 |
| **2019/2020** | 1 | 1 | 6 | 14 | 14% | 7% | 0.22 |
| **2016-2020** | **5** | **3** | **26** | **54** | **16%** | **5%** | **0.26** |

NDVI_feat

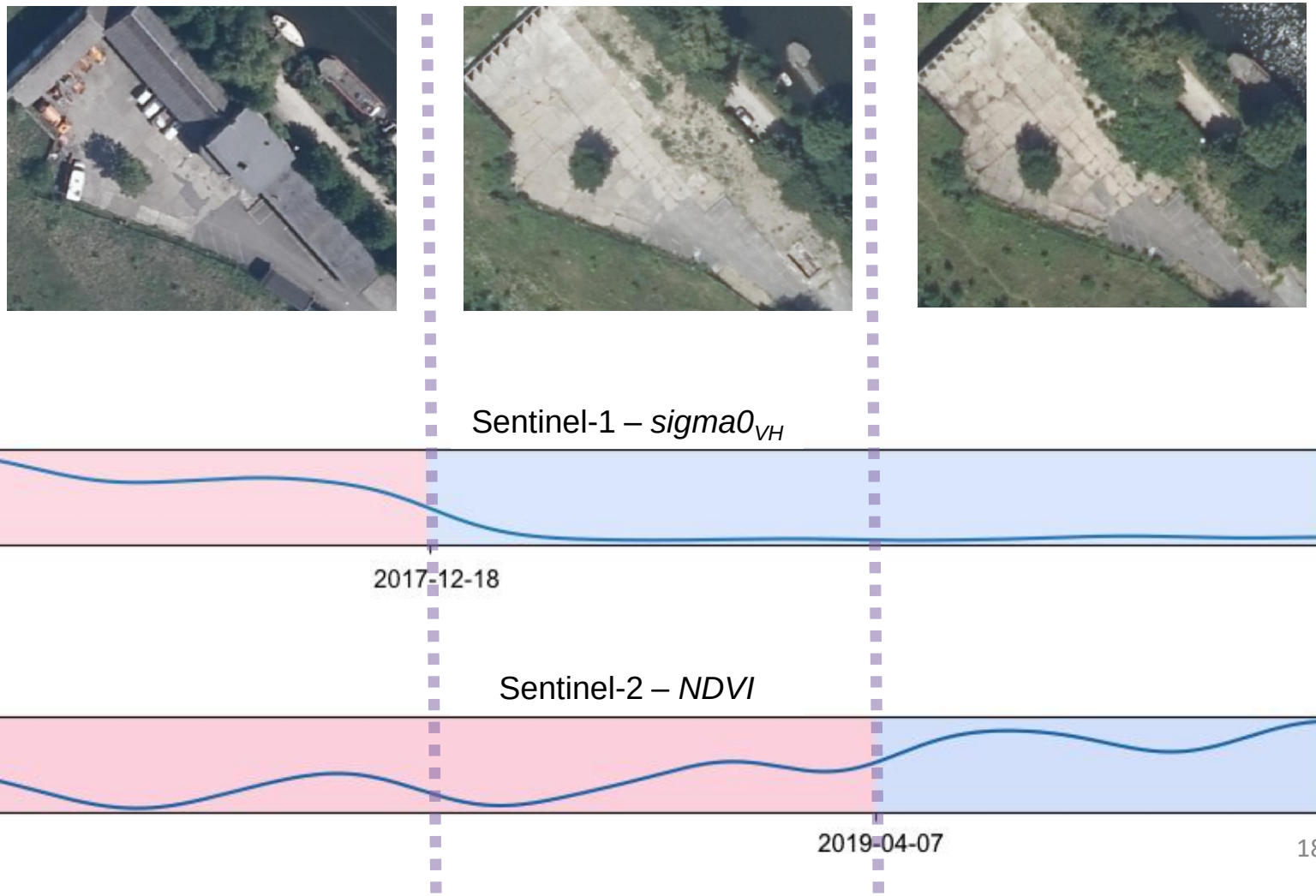
| Year | TP | FP | FN | TN | TPR | FPR | $F_1$-score |
|---|---|---|---|---|---|---|---|
| **2016/2017** | 3 | 0 | 4 | 15 | 43% | 0% | 0.55 |
| **2017/2018** | 8 | 2 | 3 | 9 | 73% | 18% | 0.76 |
| **2018/2019** | 2 | 2 | 4 | 14 | 33% | 13% | 0.40 |
| **2019/2020** | 3 | 0 | 4 | 15 | 43% | 0% | 0.60 |
| **2016-2020** | **16** | **4** | **15** | **53** | **52%** | **7%** | **0.63** |

Sigma0_VH_feat + NDVI_feat

| Year | TP | FP | FN | TN | TPR | FPR | $F_1$-score |
|---|---|---|---|---|---|---|---|
| **2016/2017** | 6 | 1 | 1 | 14 | 86% | 7% | 0.86 |
| **2017/2018** | 8 | 3 | 3 | 8 | 73% | 27% | 0.73 |
| **2018/2019** | 3 | 1 | 3 | 15 | 50% | 6% | 0.60 |
| **2019/2020** | 3 | 0 | 4 | 15 | 43% | 0% | 0.60 |
| **2016-2020** | **20** | **5** | **11** | **52** | **65%** | **9%** | **0.71** |

# 3. Changepoint detection – Example

## “Service voirie d'Angleur”, Liège



# 3. Change detection – Phase 2 (All sites)

- Ground truth (orthophotos 2016-2018)

| ID_Segment | Site Name | SAR_Ortho_GroundTruth | SAR_Ortho 2016 vs 2018 (% for each class) | | | Change |
|---|---|---|---|---|---|---|
| | | CODE | Vegetation | Building | Soil | |
| 52011-ISA-0015-01 | Administration Cockerill | 000 | 0 | 0 | 0 | 0 |
| 52011-ISA-0032-01 | Cinéma-Théatre Varia | 000 | 0 | 0 | 0 | 0 |
| 52011-ISA-0040-01 | Cordial Bowling | 203 | 100 | 0 | -100 | 1 |
| 52012-ISA-0011-01 | Hangars Vanbelle | 332 | -5 | -35 | 40 | 1 |
| 52021-ISA-0007-01 | Charbonnage de Soleilmont | 000 | 0 | 0 | 0 | 0 |
| 52021-ISA-0008-01 | Charbonnage du Petit-Try | 000 | 0 | 0 | 0 | 0 |
| 62003-ISA-0004-01 | Ets Fraikin | 000 | 0 | 0 | 0 | 0 |
| 62063-ISA-0034-01 | Renory Zone A | 232 | 5 | -30 | 25 | 1 |
| 62063-ISA-0037-01 | Parking Jonfosse | 323 | -10 | 100 | -90 | 1 |
| 62063-ISA-0098-01 | Boliden - Cuivre et Zinc | 000 | 0 | 0 | 0 | 0 |
| 62063-ISA-0181-01 | Centre sportif du Grand Séminaire | 000 | 0 | 0 | 0 | 0 |
| 62063-ISA-0189-01 | Cigares Grétry Taf | 000 | 0 | 0 | 0 | 0 |
| 62063-ISA-0201-01 | Bâtiment de la rue Pré Binet | 000 | 0 | 0 | 0 | 0 |
| 62063-ISA-0230-01 | Marché couvert d'Amercoeur | 203 | 15 | 0 | -15 | 1 |
| 62063-ISA-0247-01 | Service voirie d'Angleur | 032 | 0 | -35 | 35 | 1 |
| 62093-ISA-0026-01 | Puits de mine - rue Renson | 000 | 0 | 0 | 0 | 0 |
| 62096-ISA-0038-01 | Verreries Liégeoises | 203 | 70 | 0 | -70 | 1 |
| 62096-ISA-0039-01 | Ets Linotte | 332 | -5 | -50 | 55 | 1 |
| 62096-ISA-0056-01 | Maison des Espagnols | 232 | 5 | -10 | 5 | 1 |
| 62118-ISA-0002-01 | Ets Frankignoul | 223 | 25 | 15 | -40 | 1 |
| 52012-ISA-0017-02 | Charbonnage n°10 du Gouffre | 000 | 0 | 0 | 0 | 0 |
| 62096-ISA-0052-02 | Haut Fourneau 6 | 032 | 0 | -20 | 20 | 1 |
| 25005-ISA-0001-02 | Hangar La Comete | 000 | 0 | 0 | 0 | 0 |
| 25005-ISA-0003-01 | Entreprise de voirie Van Brabant | 011 | 0 | 0 | 0 | 1 |
| 25014-ISA-0001-01 | Entrepôts militaires à Lillois | 302 | -5 | 0 | 5 | 1 |
| 25014-ISA-0002-01 | Etablissement Stiens Roger | 203 | 35 | 0 | -35 | 1 |
| 25014-ISA-0003-01 | Établissement Defalque et fils | 000 | 0 | 0 | 0 | 0 |
| 25014-ISA-0005-01 | Filature de coton Allard | 001 | 0 | 0 | 0 | 1 |
| 25014-ISA-0007-01 | Établissements Denolin n°1 | 000 | 0 | 0 | 0 | 0 |
| 25014-ISA-0009-01 | Tannerie Disbeck | 032 | 0 | -100 | 100 | 1 |

# 3. Change detection – Phase 2 (All sites)

- Results (2291 sites)

| Features | TP | FP | FN | TN | TPR | FPR | $F_1$-score |
|---|---|---|---|---|---|---|---|
| NDVI-NDWI2-VH-VV | 973 | 672 | 240 | 406 | 80% | 62% | 0.68 |
| NDVI-NDWI2-VH | 943 | 626 | 270 | 452 | 78% | 58% | 0.68 |
| NDVI-NDWI2-VV | 932 | 629 | 281 | 449 | 77% | 58% | 0.67 |
| NDVI-VH-VV | 751 | 414 | 462 | 664 | 62% | 38% | 0.63 |
| NDWI2-VH-VV | 619 | 308 | 594 | 770 | 51% | 29% | 0.58 |
| NDVI-VH | 677 | 349 | 536 | 729 | 56% | 32% | 0.60 |

- Results (1922 sites > 500m$^2$)

| Features | TP | FP | FN | TN | TPR | FPR | $F_1$-score |
|---|---|---|---|---|---|---|---|
| NDVI-NDWI2-VH-VV | 908 | 541 | 195 | 278 | 82% | 66% | 0.71 |
| NDVI-NDWI2-VH | 880 | 509 | 223 | 310 | 80% | 62% | 0.71 |
| NDVI-NDWI2-VV | 869 | 510 | 234 | 309 | 79% | 62% | 0.70 |
| NDVI-VH-VV | 698 | 343 | 405 | 476 | 63% | 42% | 0.65 |
| NDWI2-VH-VV | 574 | 244 | 529 | 575 | 52% | 30% | 0.60 |
| NDVI-VH | 631 | 290 | 472 | 529 | 57% | 35% | 0.62 |

# 3. Change Detection – What's next

- Analysis and removal of FPs/FNs
  - Correlation between errors and
    - vegetation seasonality
    - type of change
    - size of the RDS
- Segmentation
  - New tests for the entire dataset
    - due to the heavy workload, a hybrid approach where only big sites are segmented will be considered

# 4. Change Classification

## Investigations

- General:
  - Sentinel-2 data
  - Terrascope capabilities
- What:
  - 22 test sites
  - 13 indexes:
    (NDVI, SAVI, NDWI, NDWI2, NDBI, NBAI, NBI, BAI, BI, BI2, CI, BSI & SBI)
  - Tests on full sites as well as on IBA, PICC, PICC&Grid, Grid_Only & WALOUS segmentations
  - Mean, Median and Standard-deviation calculation

→ profile analysis to determine the best way to qualify the changes

# 4. Change Classification

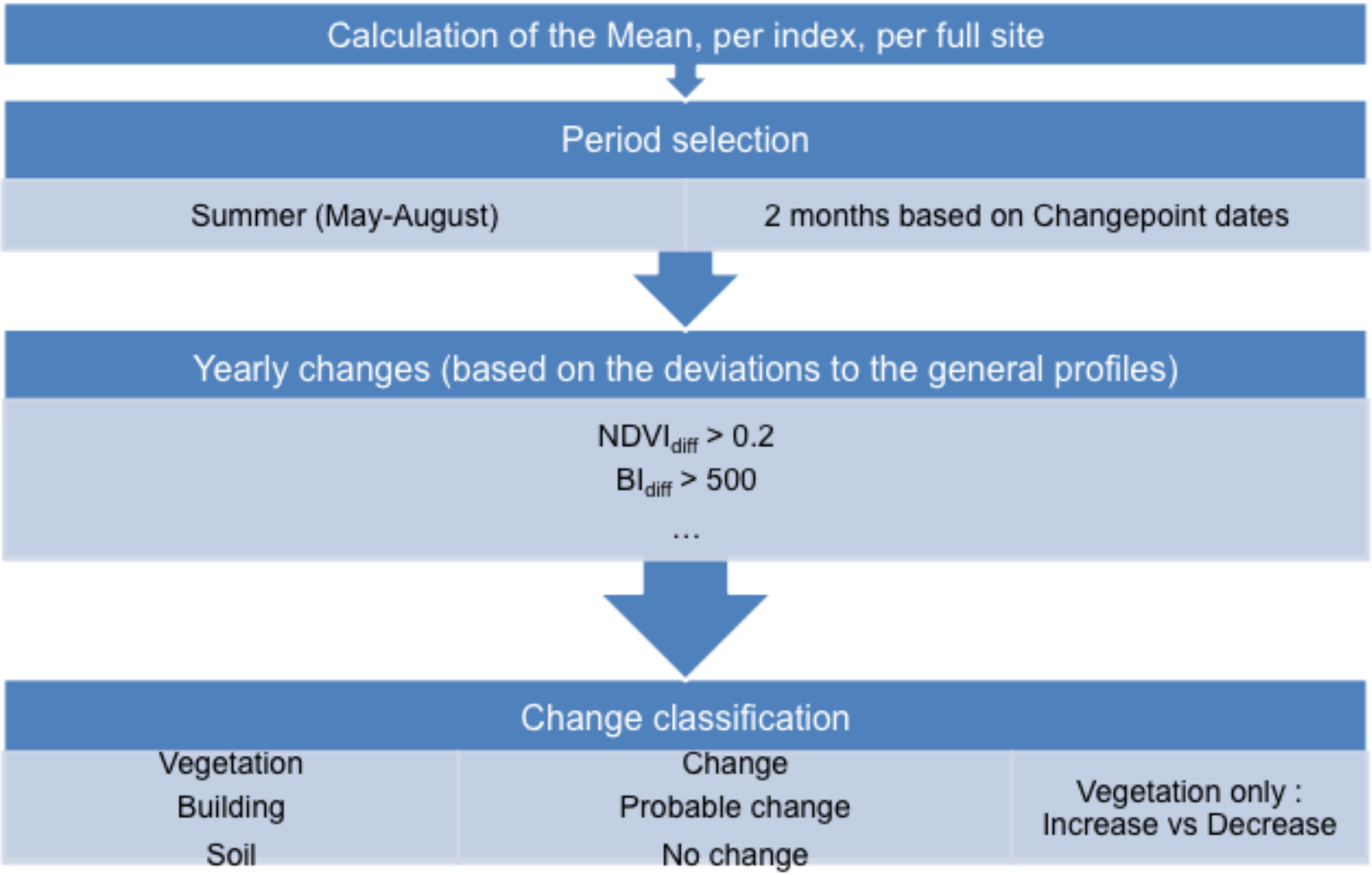
Methodology

- Focus on the **Vegetation, Building & Soil** classes
- 5 indexes selected :
  - Normalized Vegetation Index (NDVI)
  - Built-up areas index (BAI)
  - Brightness Index (BI)
  - Second Brightness Index (BI2)
  - Soil brightness index (SBI)

→ Mean per index per full site
→ Determination of the general profile per index and deviations indicating changes
→ Yearly comparison

# 4. Change Classification

## Methodology



# 4. Change Classification

## Ground Truth: 214 sites

- Ortho-photos
  - Selection of sites (from the SAR project) with the most important changes (> 500m²)
  - Summer 2016 to summer 2018 changes
  - Spread all over Wallonia
- Pleiades images
  - Sites with changes and with no changes
  - Summer 2019 to summer 2020 changes
  - All the site in Liège area for which we have images
- Type of Changes:
  - Increase & decrease for vegetation
  - Change for building and soil

| Source | Vegetation | Building | Soil |
|---|---|---|---|
| Ortho-photos | 72 | 70 | 82 |
| Pleiades | 6 | 6 | 5 |
| **TOTAL** | **78** | **76** | **87** |

# 4. Change Classification

## Results

| Type of change | Ground truth | Change properly classified | True Positive Rate |
|---|---|---|---|
| Vegetation change | 78 | 74 | 95% |
| Vegetation Increase | 13 | 11 | 85% |
| Vegetation Decrease | 63 | 65 | 97% |
| Building | 76 | 30 | 39% |
| Soil | 87 | 62 | 71% |

→ confusion between building & soil

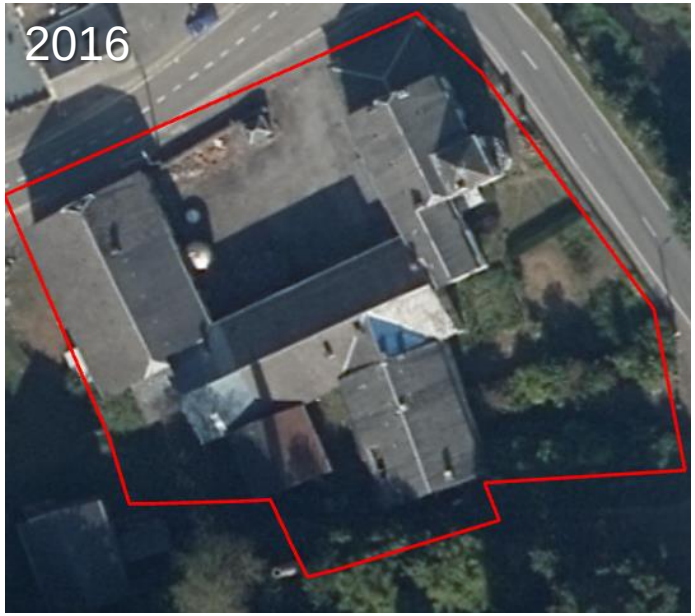
| Type of change | Ground truth | Change properly classified | True Positive Rate |
|---|---|---|---|
| Building & Soil | 102 | 80 | 78% |

| Class | Vegetation | Building | Soil | No Change | Total | Commission Errors |
|---|---|---|---|---|---|---|
| **Vegetation** | 74 | 0 | 0 | 0 | 74 | 0% |
| **Building** | 0 | 30 | 13 | 1 | 44 | 32% |
| **Soil** | 0 | 27 | 62 | 2 | 91 | 32% |
| **No Change** | 4 | 19 | 12 | 398 | 433 | 8% |
| **Total** | 78 | 76 | 87 | 401 | 642 | |
| **Omission Errors** | 5% | 61% | 29% | 1% | | **OA = 87.9%** |

# 4. Change Classification

## Example of results

- Site with vegetation & building & soil changes (ortho 2016-18)
  - Vegetation: “decrease”
  - Building: “change”
  - Soil: “probable change”



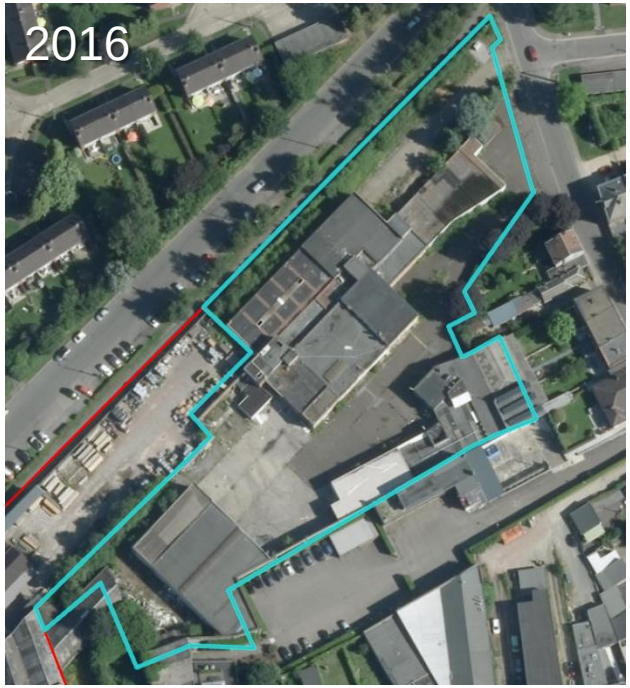


84033-ISA-0006-01
Brasserie Pierrard

# 4. Change Classification

## Example of results

- Site with vegetation & building & soil changes (ortho 2016-18)
  - Vegetation: “decrease”
  - Building: “change”
  - Soil: “probable change”





62038-ISA-0012-01
Abattoir de porcs
Marquet-Lovinfosse

# 4. Change Classification

## What's next

- Investigation for the building type of change
  - Modifications in the calculation of standard profile deviation
  - Combination of features to create one indicator for building & soil
- Results for the entire dataset
- Type of change determination outside summer

  → Analysis of all the RDS for which we have a change date (obtained in the change detection phase) and Pleiade images as ground truth

# 4. Change Classification

## Additional information

- Amplitude of the change
  - Use of the change/Probable change indicator
  - Use of the value of the standard profile deviation

- Confidence in the change
  - Higher confidence when a type of change is detected
  - Higher confidence to the type of change detection when summer information
  - Confidence depending on the amplitude of the change

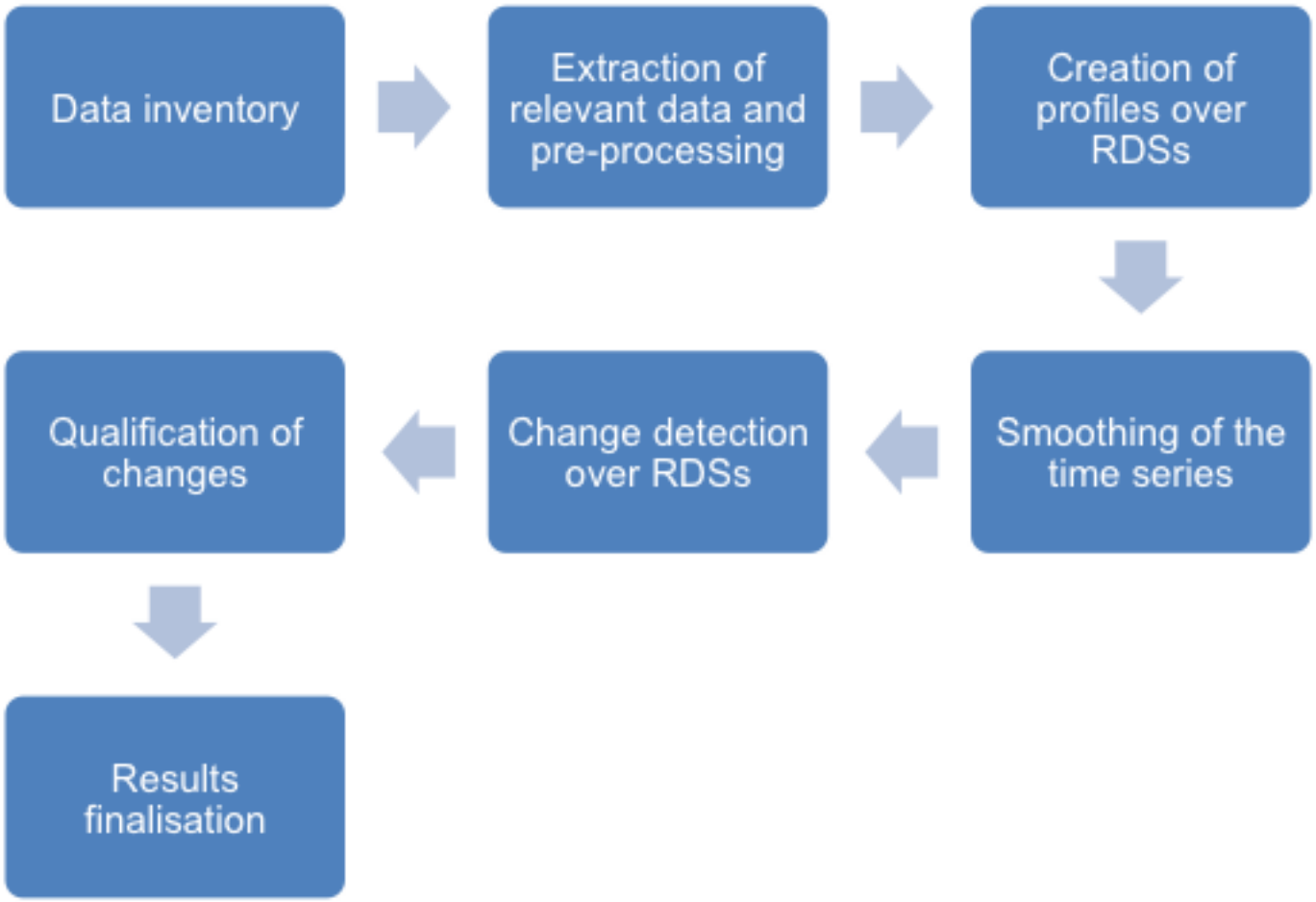
# 5. Platform integration

## What platform do we use to develop the tool?


- Belgian contribution to the Sentinel Collaborative Ground Segment
- Virtual Research Environment (python)
- Availability of preprocessed S1 & S2 images
- Likely « modest » processing requirements
- Long-term maintenance

# 5. Platform integration

## What will the final tool do ?



# 5. Platform integration

## 1. 'SQLite' method

**Terrascope standard package**

+ Compatible with the standard Terrascope package

- Less stable
- Less efficient (long computation time because it requires a lot of disk accesses)
- SQLite is only accessible to one person (or software) at a time

→ **Research and development phase**

## 2. 'PostGIS' method

**Terrascope + PostGIS/PostgreSQL**

+ More stable

+ More efficient

+ PostgreSQL is accessible to several people (or software) at the same time

+ More development perspectives (ex. Webservice)

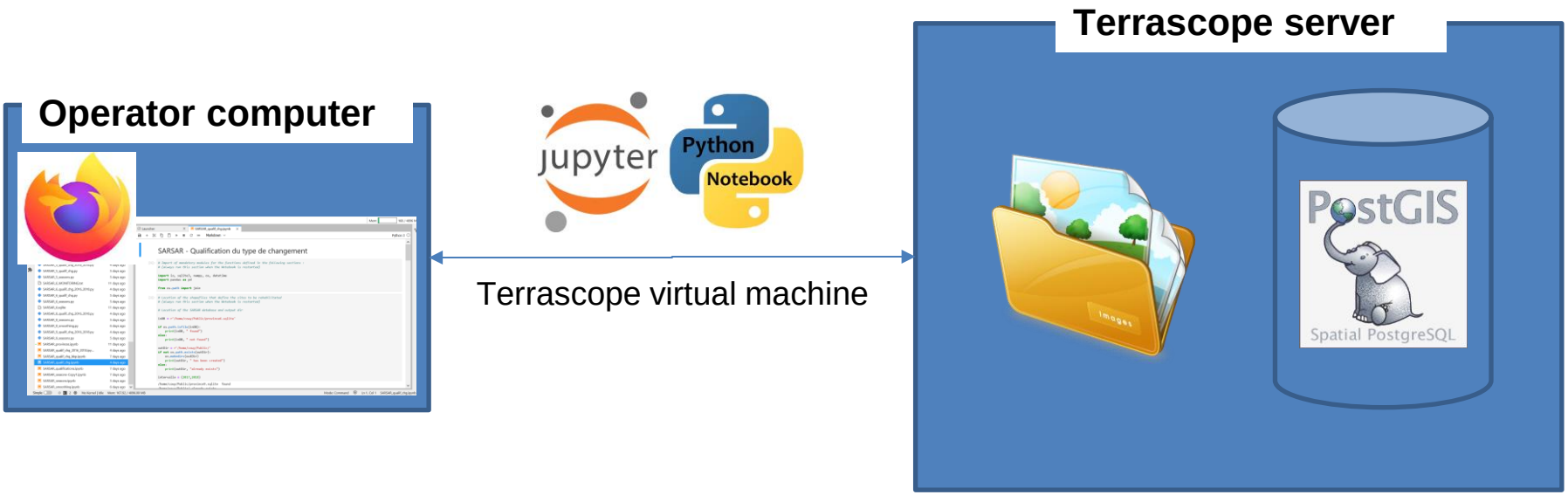
- Requires resources that are not part of the standard package for Terrascope users
- Use of more qualified personnel for implementation and maintenance

→ **Production phase**

# 5. Platform integration

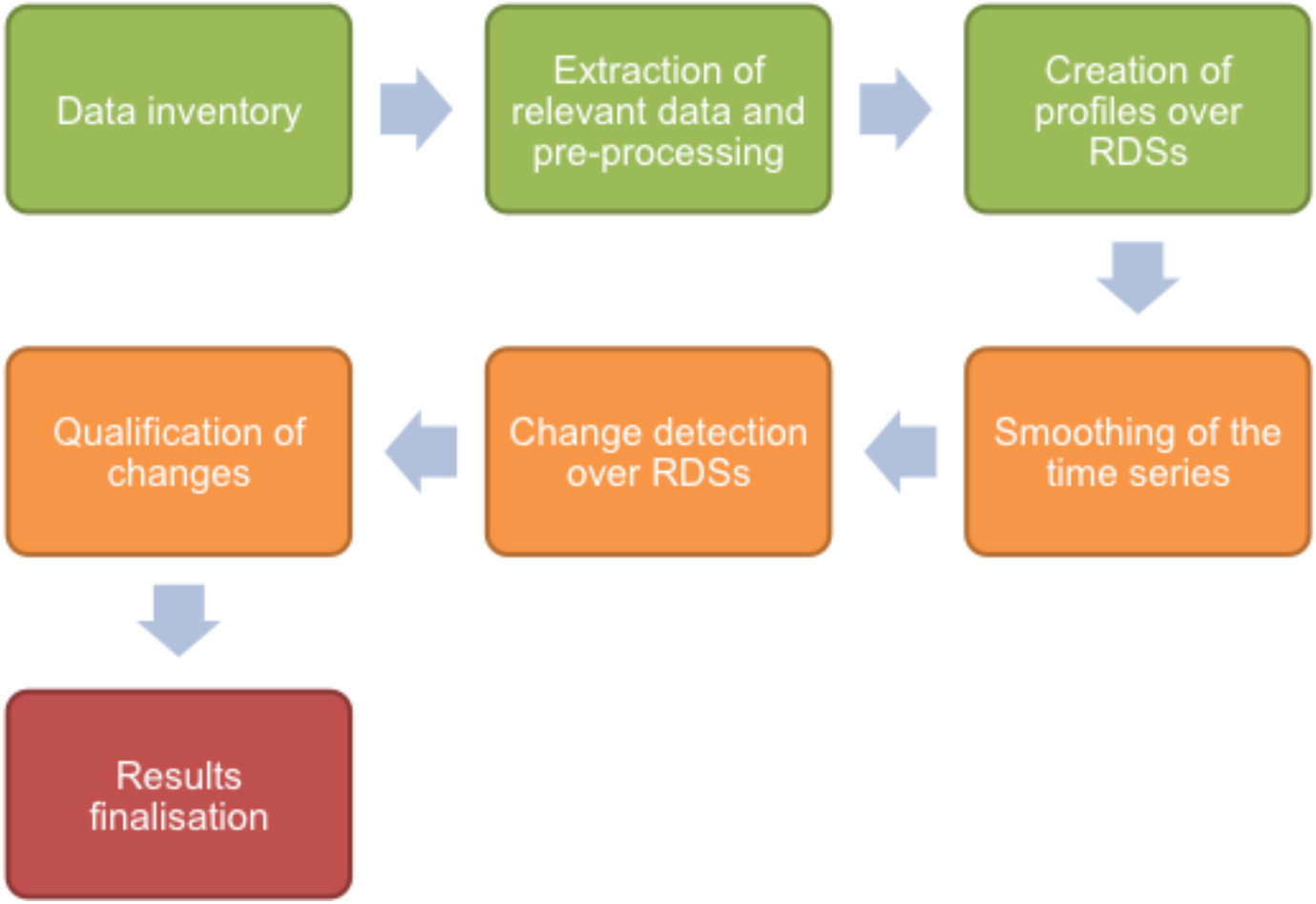
## Final choice : 'PostGIS' Method

- Semi-automatic
- Controlled by the operator



# 5. Platform integration

## Where are we now with the 'PostGIS method'?



# 5. Platform integration

## Valorisation/knowledge sharing ?

→ Publication of software and VM configuration:

to provide the opportunity for the community to access the developments made in the framework of our project

→ Terrascope Jupyter notebook:

Production of an operational example of Jupyter Notebook meant to be reused in other projects

BELGIAN EARTH OBSERVATION

# SARSAR – SR/00/372

## Automatic redevelopment sites monitoring using SAR and OPTICAL images

**WP4 – Technology transfer**
**WP5 – Dissemination**

Steering Committee Meeting - 19th March 2021

# WP4 – Technology transfer

## User Manual & Training Session

- Description:
  - "Transfer the developed tool to the end-user. This imply regular meeting with the end-user to fine-tune the tool to his need. It also consists in ensuring the end-user is actually able to use the tool, that the end-user is able to understand the results provided by the tool and understand the limitations."
- Objectives:
  - "Guarantee the tool fits the need of the end user"
  - "Guarantee the end-user can use the tool, understands its results and its limitations"
- Methodology:
  - "user manual will be written describing how to use the tool, the environmental requirements (IT infrastructure), how to interpret the results and the limitation of the tool;
  - In addition, training sessions on how to use the tool will be organised."

# WP4 – Technology transfer

- Documentation on the methodology:
  - Information on Terrascope Interface
  - Jupyter Notebooks for Python scripts
  - Information on the ‘PostGIS’ method

- Documentation on the results:
  - User manual in pdf

# WP4 – Technology transfer

- Meetings with the users to fine-tune the technology transfer
- Nice to have:
  - WFS
  - Alert system on the RDS website
- Trainings (Face-to-face):
  - ½ to 1 day
  - Theoretical and practical parts
  - Working Groups

→ Depending on the Covid-19 situation

→ Project prolongation?

# WP5 – Dissemination

## Publication & User workshop

- Description:
  - "Redaction of scientific papers and contribution to conferences and workshops, organization of a seminar for the Walloon Region / DGO4."
- Objectives:
  - "To disseminate the results"
  - "To show the capabilities of the service to the users."
- Methodology:
  - "Redaction of scientific papers and contribution to conferences and/or workshops"
  - "Organisation of a seminar to show the service to other potential users."

# WP5 – Dissemination

- Past conferences and workshops
  - GT-COWal, November 2019: first introduction to the Walloon region actors
  - Belgian Earth Observation Day 2019
  - URSI Benelux Forum 2019
  - CISS Lecture Series 2020
- Future conferences and workshops
  - EARSeL Liège 2021, March 2021: EO for sustainable cities and communities
  - IGARSS 2021
    - Organized special session “Sentinel-1/2 Multi-Temporal Analysis and Change Detection” → accepted and included in the program
    - Submitted a paper on SARSAR → accepted as oral presentation

# WP5 – Dissemination

- Planned conferences and workshops (depending on the Covid-19 situation)
  - GT-COWal
  - GTEO
  - User workshops for the Walloon Region
  - Valorization of the developments conducted in the Terrascope environment

# WP5 – Dissemination

## Collaboration with other projects

- SARSAR is deeply linked to the SAR project
  - CHANGE DETECTION ANALYSIS ON WALLOON BROWNFIELD SITES presented in “THE EVER GROWING USE OF COPERNICUS ACROSS EUROPE’S REGIONS, A selection of 99 user stories by local and regional authorities”, 2018
  - Video presented by Mr. Christophe Rasumny and Dr. Eric Hallot about how Sentinel-2 data are being used to support inventory and monitor the evolution of brownfield sites in Wallonia, 2019 (https://www.nereus-regions.eu/copernicus4regions/videos-2/wallonia/)
  - LE VIF, numéro 07, 18.02.2021. Mention of the SAR and SARSAR projects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Thank You