SARSAR – SR/00/372

Automatic redevelopment sites monitoring using SAR and OPTICAL images

WP2 – Dynamic Monitoring of Redevelopment Sites

Overview

1. Methodology
2. Implementation
3. RDS shapefile and test sites
4. Sentinel-2 examples
5. Sentinel-1 examples
6. Preliminary Results
7. Follow-up

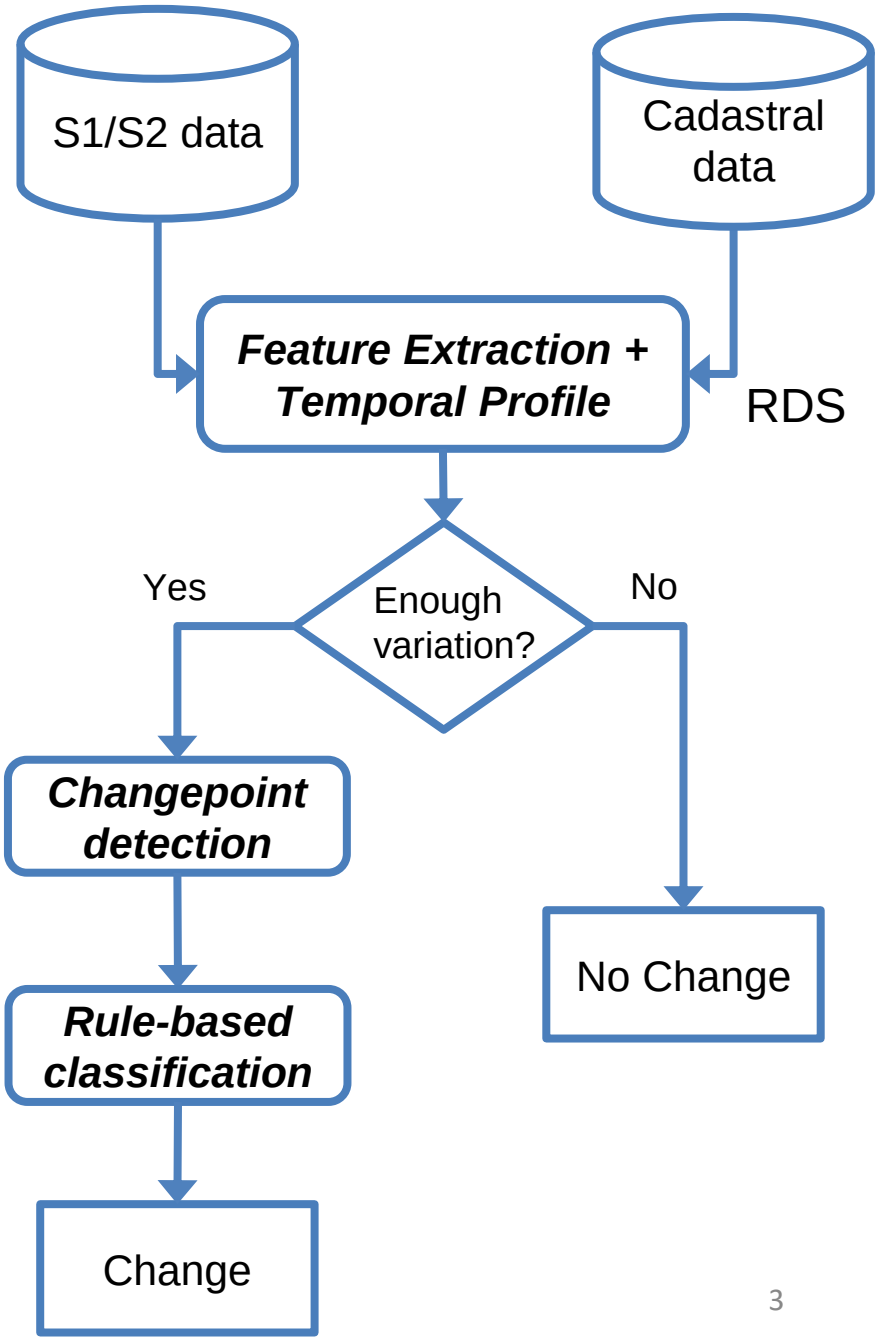
1. Methodology

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

a) Feature extraction + Generation of temporal profiles

b) Changepoint detection

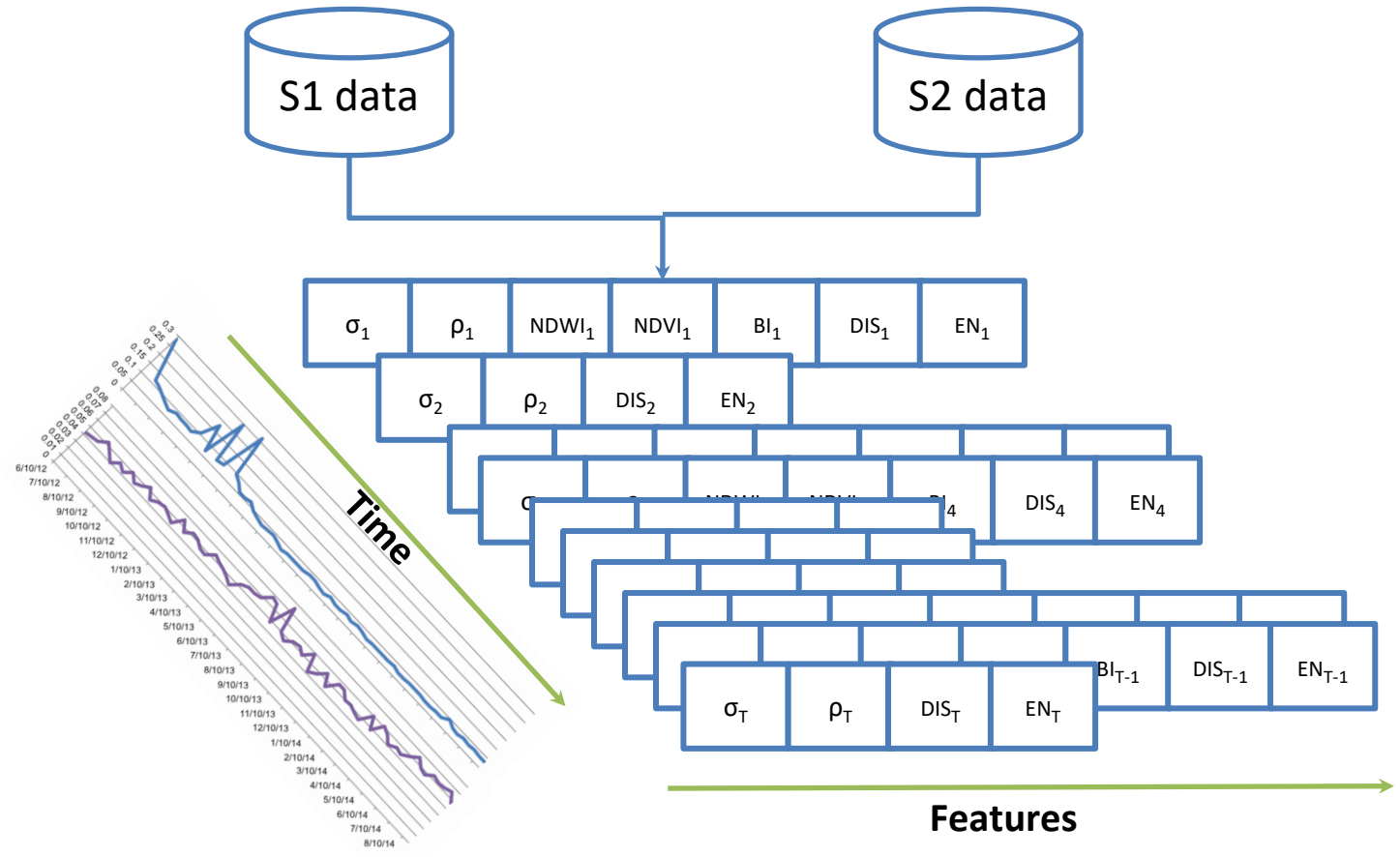
c) Rule-based classification



1. Methodology - Feature extraction

- Adaptive Feature Aggregation

  Feature vector of variable size, for each parcel



$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

$$BI = \frac{(RED + BLUE) - GREEN}{(RED + BLUE) + GREEN}$$

$$DIS = \sum_{i,j=0}^{N-1} P_{i,j} |i - j|$$

$$EN = \sum_{i,j=0}^{N-1} P_{i,j} (-\ln P_{i,j})$$

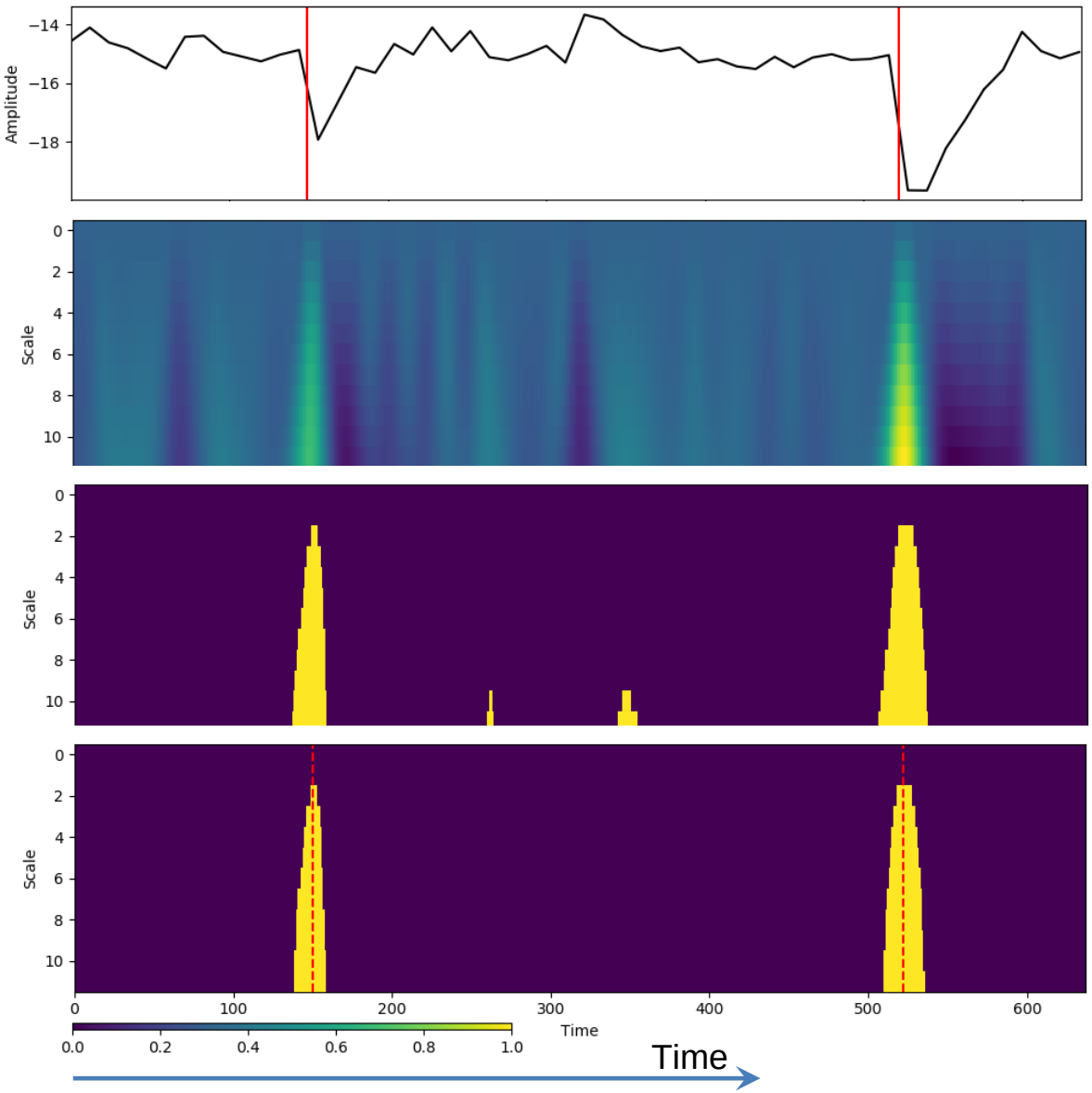
1. Methodology - Changepoint detection

Sigma0

Continuous Wavelet transform

Thresholded CWT

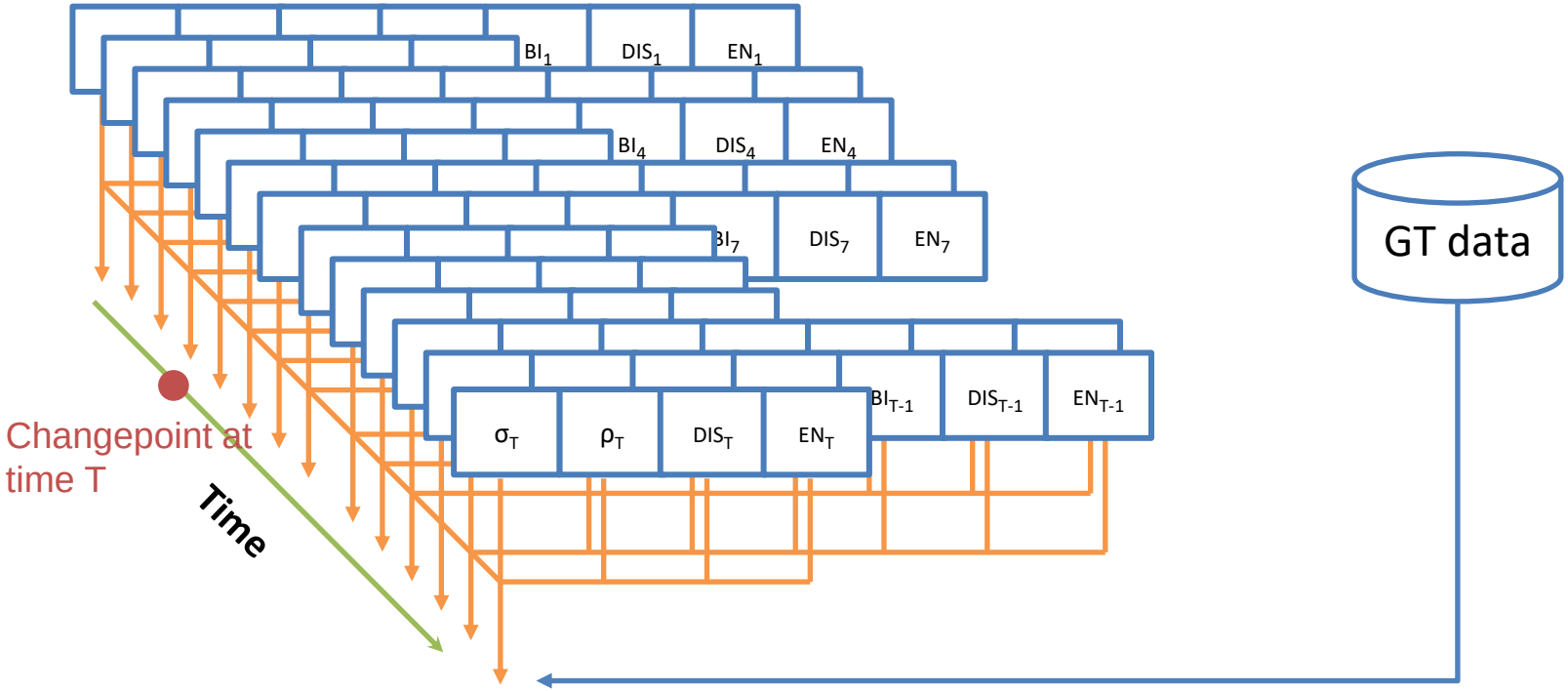
Changepoints



MM-CWT method

1. Methodology - Classification

- Classification:
  - Fuzzy Rule-based classification



Rule 1: (σ_{T+1} is low AND σ_{T-1} is high) AND (Bi_{T+1} is high AND BI_{T-1} is low) → building demolition

Rule 2: (σ_{T+1} is high AND σ_{T-1} is low) AND ($NDVI_{T+1}$ is high AND $NDVI_{T-1}$ is low) → vegetation growth

…

Rule N: (σ_{T+1} is … AND σ_{T-1} is …) AND ($NDWI_{T+1}$ is … AND $NDWI_{T-1}$ is …) → …

+ confidence parameter

2. Implementation - Terrascope

- Belgian Collaborative Ground Segment for Sentinel missions
  - Provides access to:
    - Data
    - Derived products
    - Web services
    - Processing capacity → Jupiter Notebook, **Virtual Machine**

- Available products:
  - Sentinel-1 (SLC, GRD, sigma0)
  - Sentinel-2 (ToC, LAI, fAPAR, FCOVER, NDVI)

1. Implementation - Terrascope VM

- Why?
  - Use Terrascope processing capacity → reduce costs
  - Process close to the data, avoid downloading → reduce costs & time
  - Possibility to define our own processes → flexibility, although storage can become a concern

- How?
  - Python 3.6
  - The service will run on Terrascope and the change detection report will be:
    - Sent to DG04 and ISSeP
    - Directly integrated into the DG04 IT workflow (WFS)

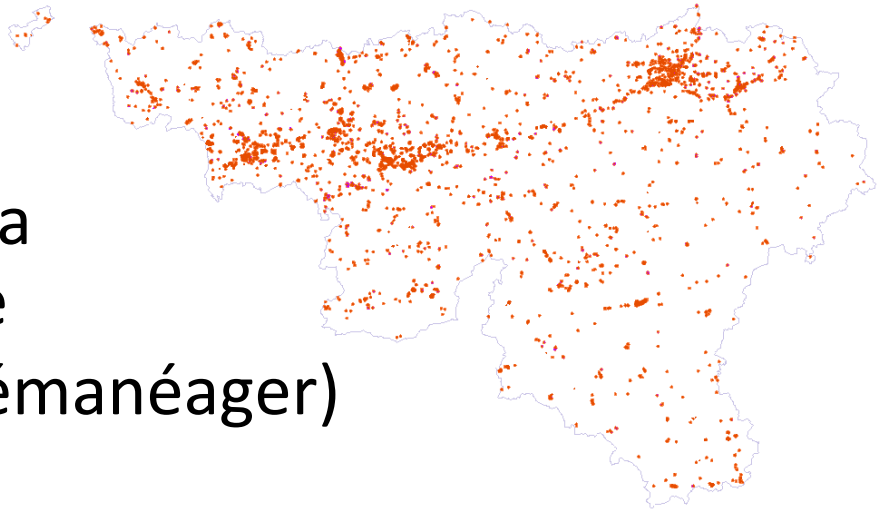
1. Implementation - Workflow

- Processing blocks (fully automatic)
  1. Read the Terrascope catalogue and RDS shapefile to extract feature and generate the temporal profiles
     → output: .csv file with temporal profiles (internal)
     → when: every week

  2. Read the temporal profiles, merge them and perform changepoint detection
     → output: .csv file with changepoints (internal)
     → when: every 2 months

  3. Rule-based classification and evaluation of changes
     → output: .csv file with report on changes
     → when: after changepoint detection

3. RDS Shapefile



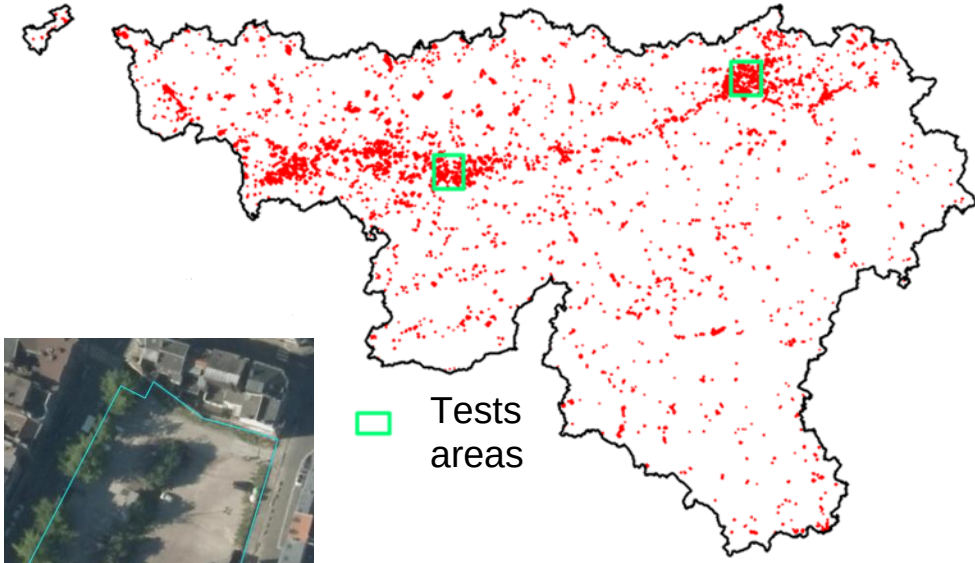
- 2017: 2213 RDS over 3800ha
- Shapefile from ISA database
- ISA (Inventaire des sites à rémanéager)
  - Historical perimeters of RDS
  - Part of the RDS inventory

Source: WalOnMap

SAR shapefile

3. Test sites

- Selection of 21 tests sites in 2 areas:
  - Liège
  - Charleroi



- 10 with majors changes

2016

2018

4. Sentinel-2 vs Ortho-photos

2016 (2016/07/20) – Ortho-photos

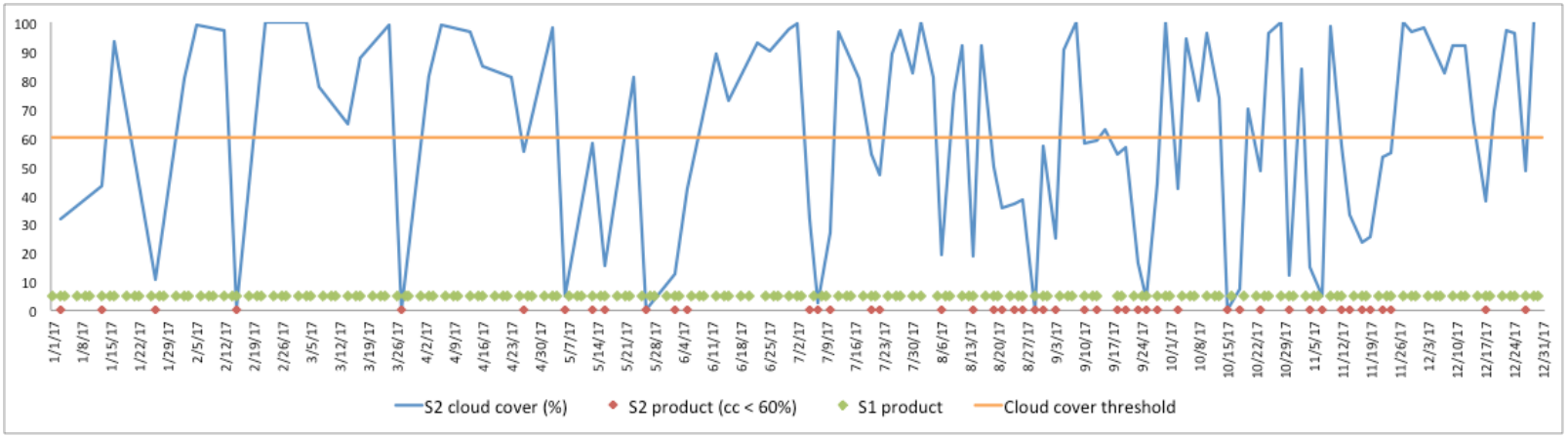
2018 (2018/06/26) – Ortho-photos

2016 (2016/07/20) – Sentinel-2

2018 (2016/07/02) – Sentinel-2

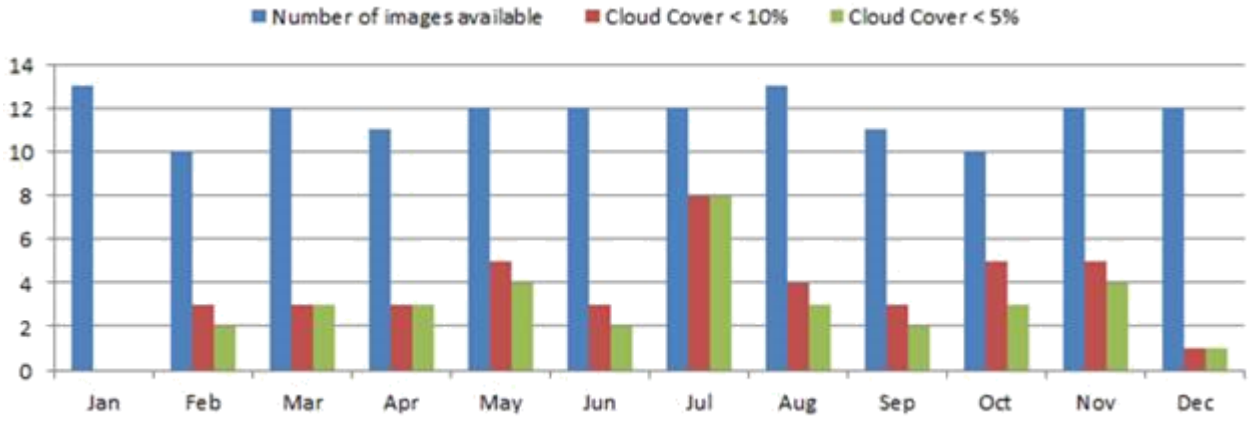
4. Sentinel-2

- Cloud cover in Wallonia (2017 Statistics)



S2 images with a cloud cover <60% → average temporal resolution of about 7.6 days for S2, but with seasonal variation

- Cloud cover on 1 single site (2018 on Liège)



Source: ISSeP

4. Sentinel-2

- First tests done with:
  - Normalized Difference Vegetation Index

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

  - Normalized Difference Built-Up Index

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

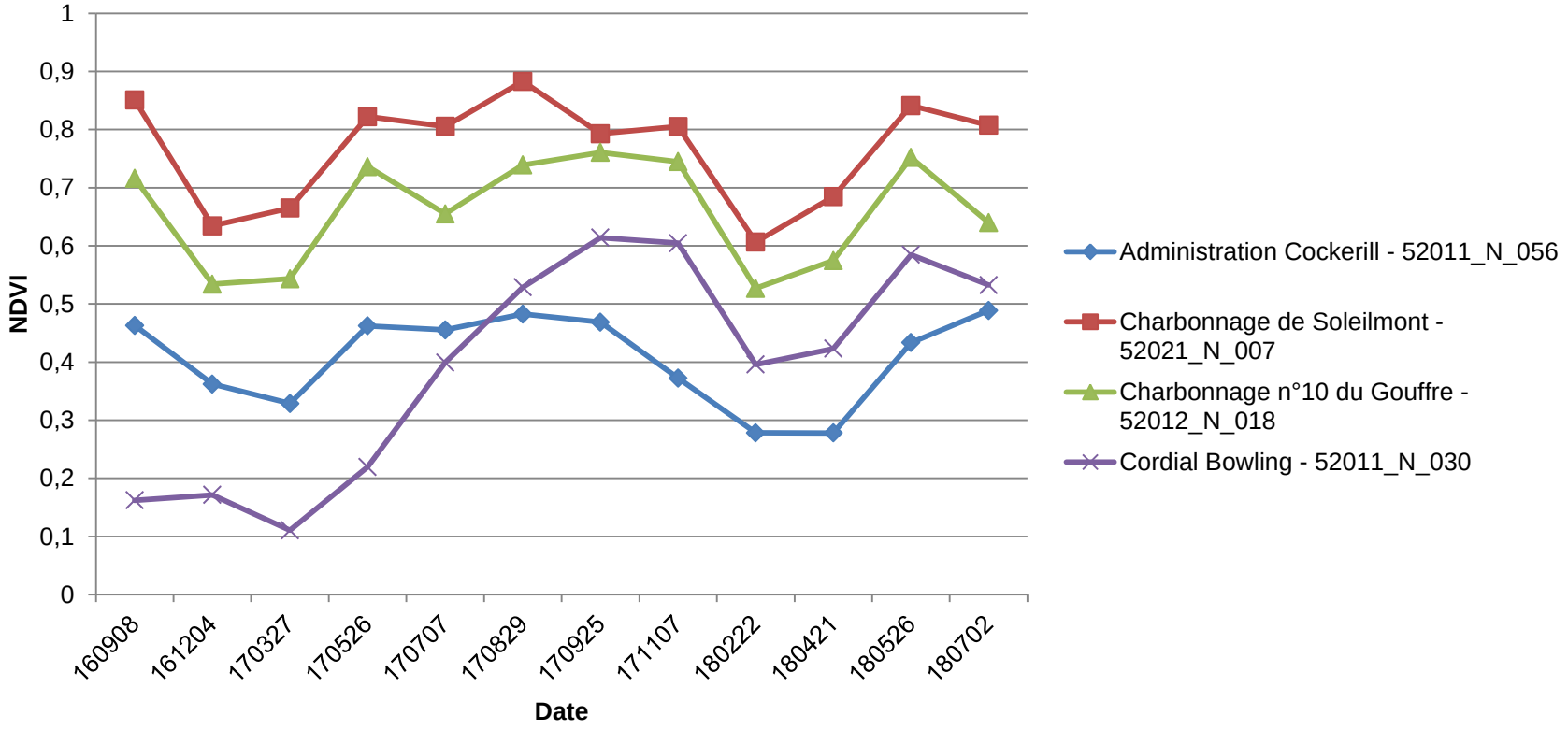
- Located on 2 different tiles (UER & UFS)
- Number of images taken into account:
  - UER: 12 images between 2016/09/08 and 2018/07/02
  - UFS: 15 images between 2016/07/20 and 2018/07/02

The dates are based on the Ortho-photos campaigns

Images cloud free, chosen to represent the general evolution of the site

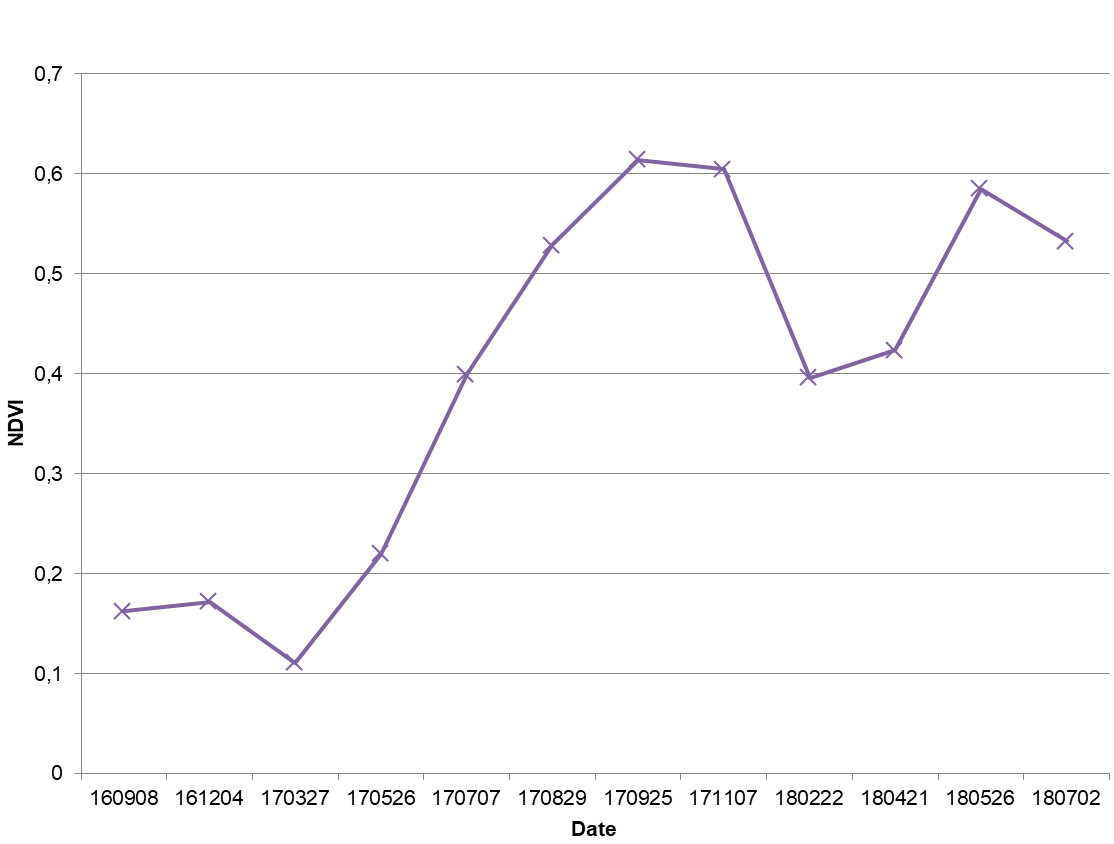
4. Sentinel-2 – Temporal profiles

- NDVI
  - Temporal profile of the NDVI mean per site:
    - 3 sites without changes
    - 1 site with changes



4. Sentinel-2 – Temporal profiles

- NDVI
  - Temporal profile of the NDVI mean per site:
    - Details of “Cordial Bowling”

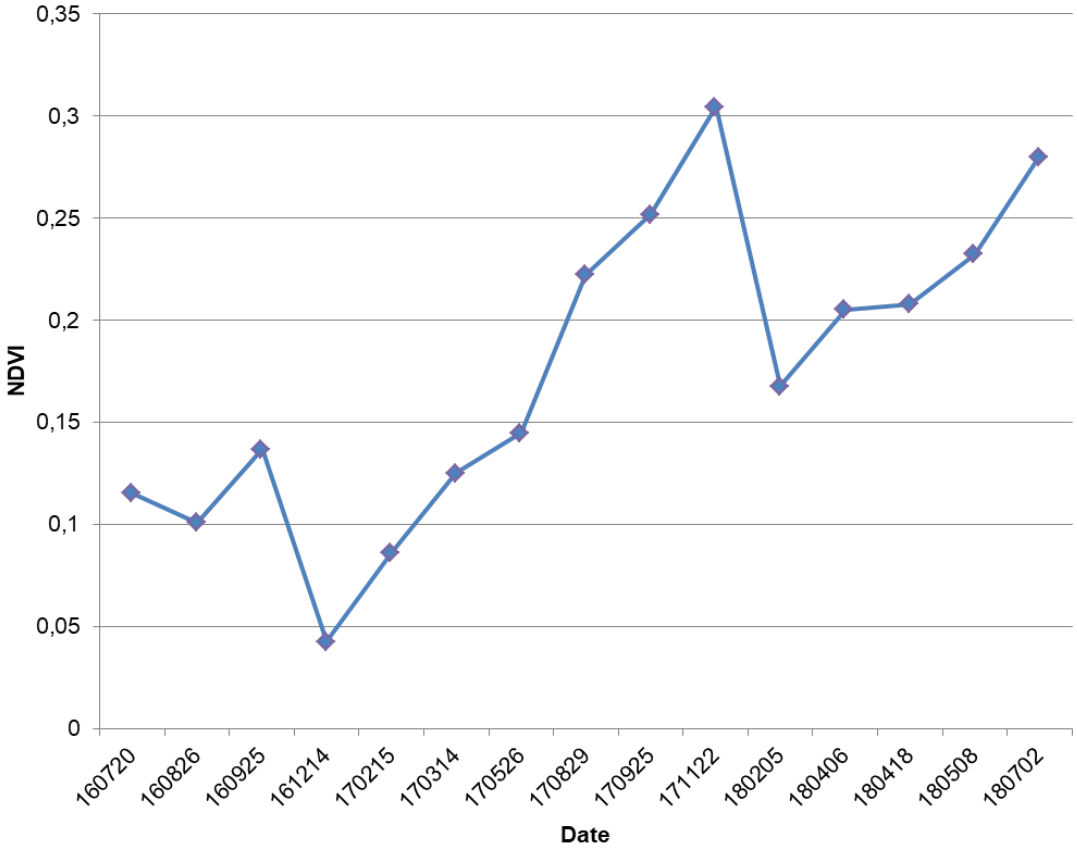


Ortho-photos 2016

Ortho-photos 2018

4. Sentinel-2 – Temporal profiles

- NDVI
  - Other example of temporal profile of the NDVI mean per site: details of “Marché couvert d’Amercoeur”

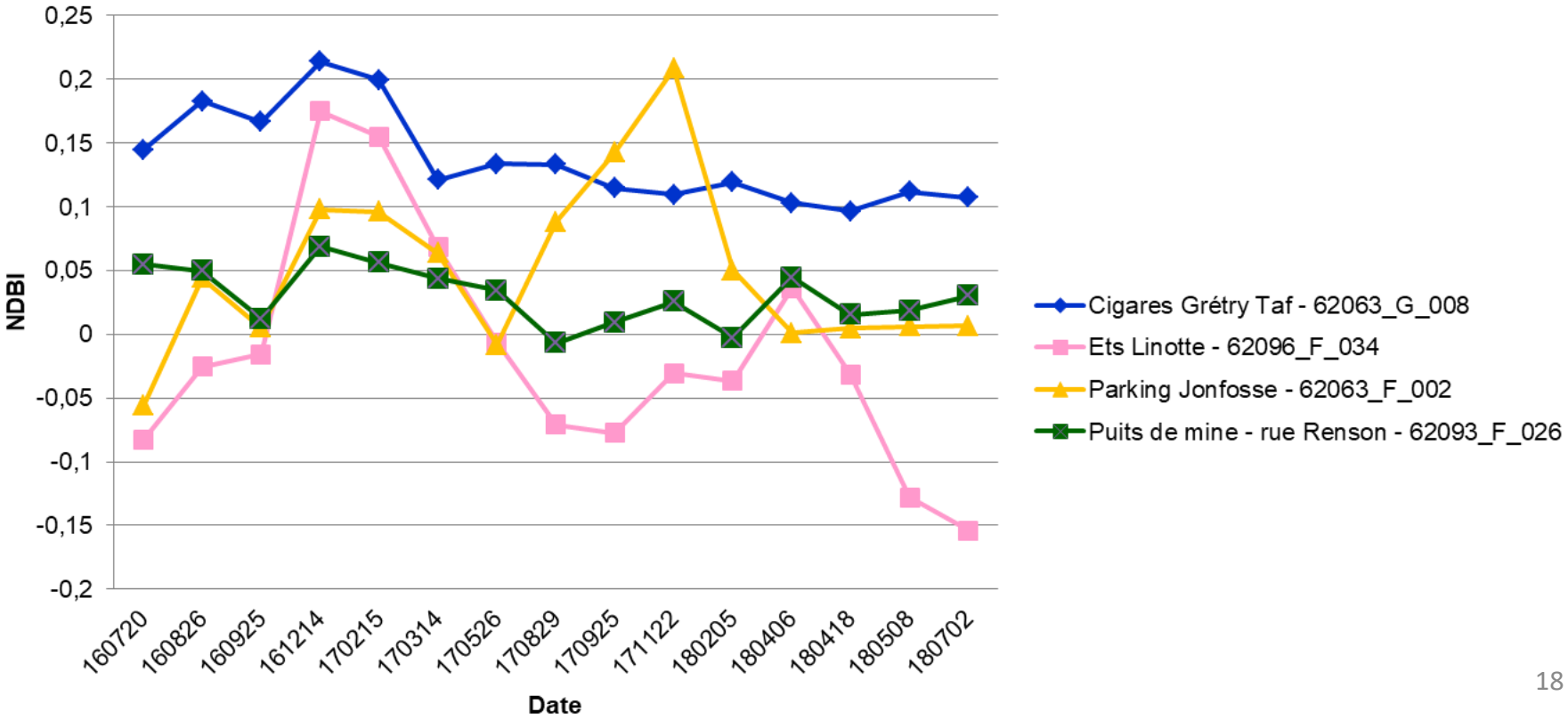


Ortho-photos 2016

Ortho-photos 2018

4. Sentinel-2 – Temporal profiles

- NDBI
  - Temporal profile of the NDBI mean per site:
    - 2 sites without changes
    - 2 site with changes



4. Sentinel-2 – Temporal profiles

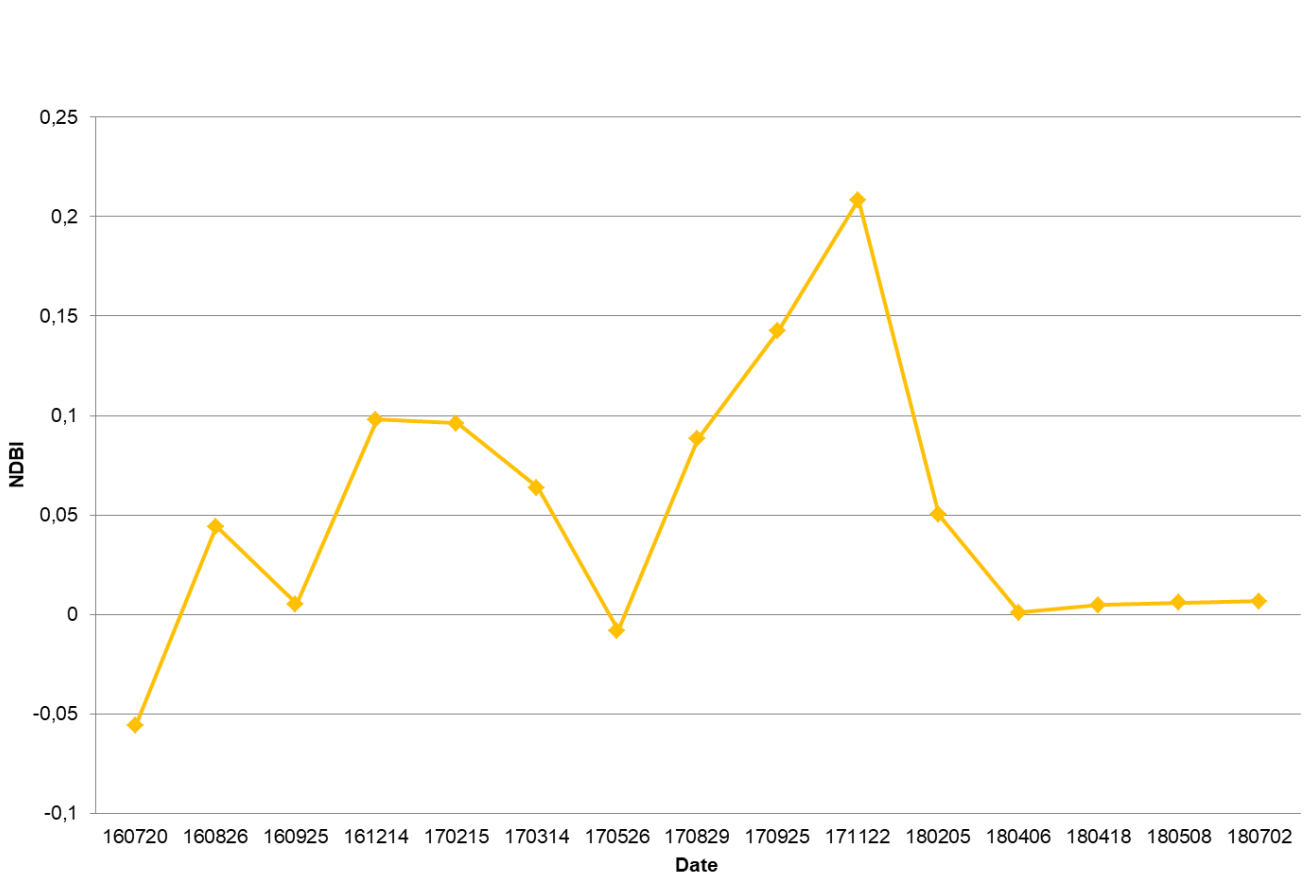
- NDBI
  - Temporal profile of the NBVI mean per site:
    - Details of “Ets Linotte”

Ortho-photos 2016

Ortho-photos 2018

4. Sentinel-2 – Temporal profiles

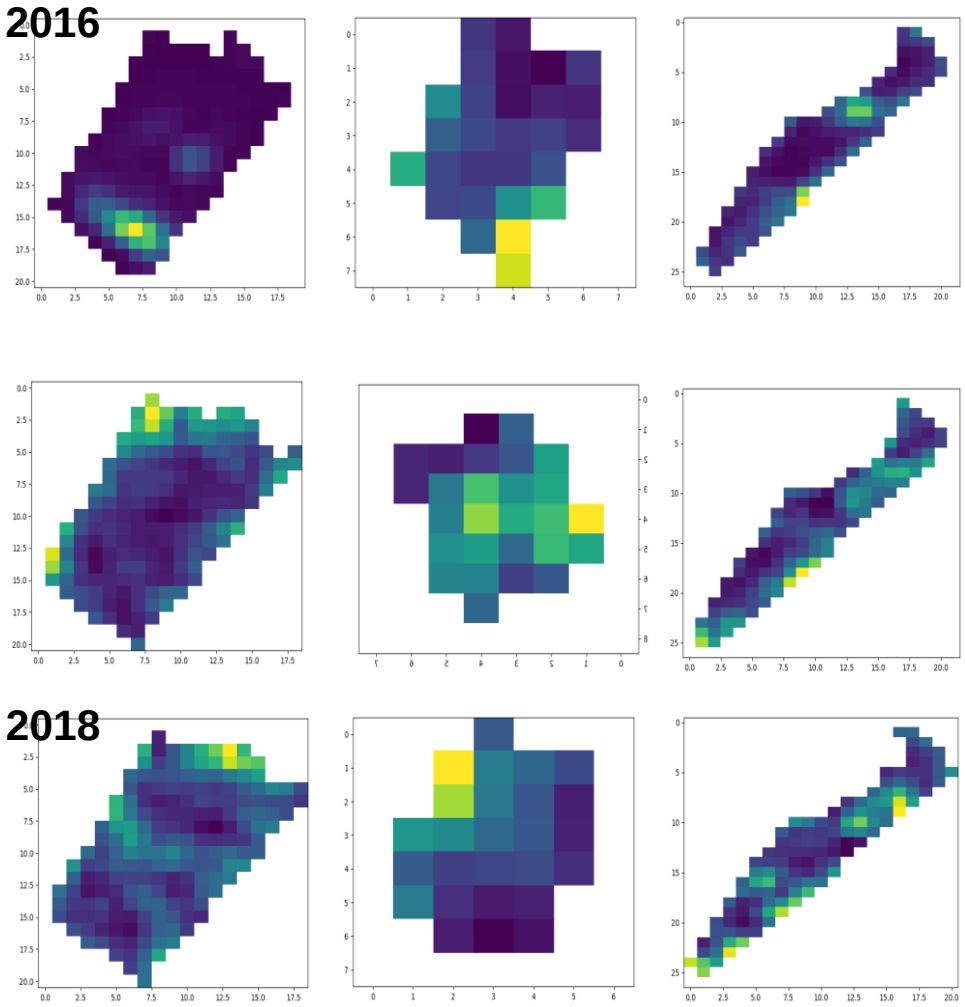
- NDBI
  - Temporal profile of the NBVI mean per site:
    - Details of “Parking Jonfosse”



Ortho-photos 2016

Ortho-photos 2018

5. Sentinel -1



Ets Linotte
62096_F_034

Parking Jonfosse
62063_F_002

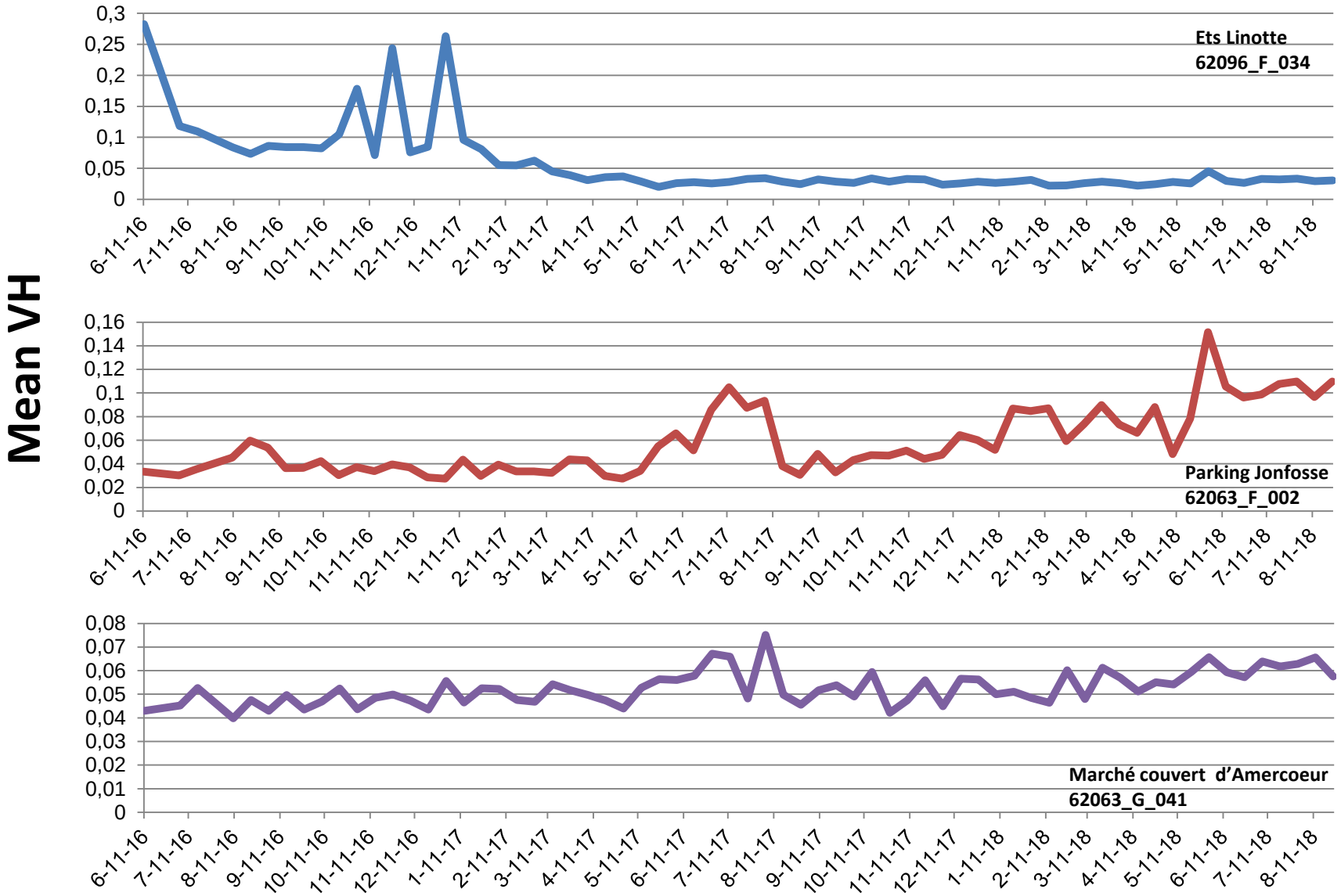
Marché couvert d'Amercoeur
62063_G_041

- Feature extraction
  - For each parcel, for each date, the features are extracted
  - Same acquisition parameters (orbit, pass)

1 feature → average sigma0 VH band

5. Sentinel-1 – Temporal profiles

- For each feature, generation of temporal profiles



6. Preliminary results – No change

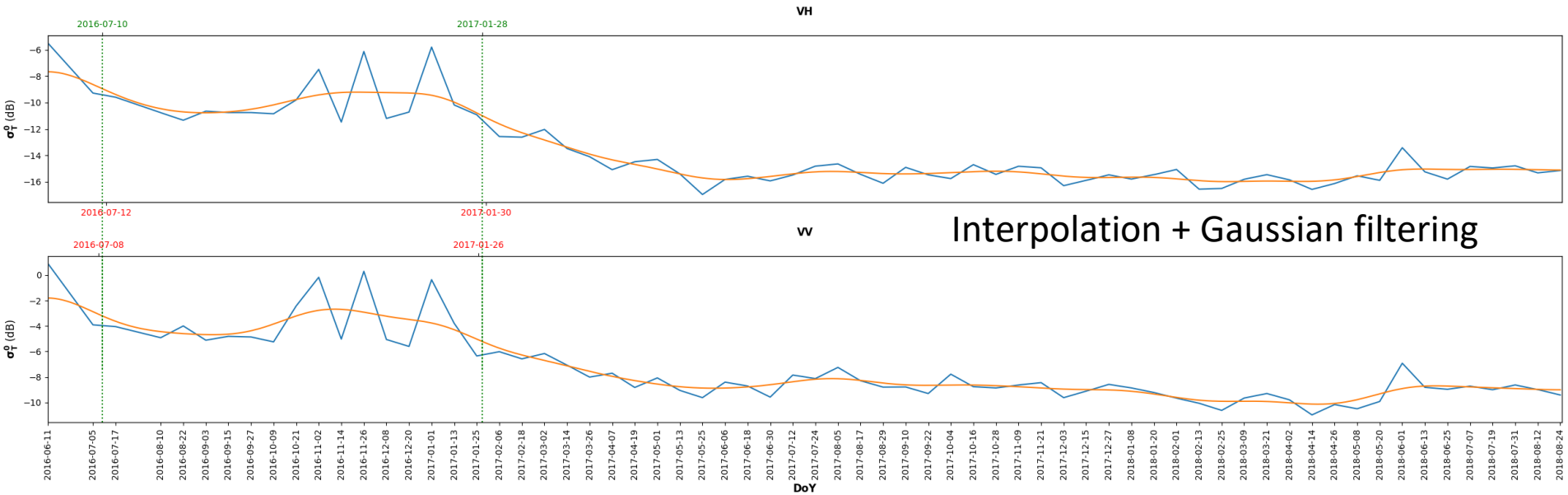
Coefficient of variation (stdev/mean) of the time series < 1%
→ No change

AOP 2016

AOP 2018

Marché couvert d'Amercoeur

6. Preliminary results – Change



Interpolation + Gaussian filtering

AOP 2016

AOP 2018

2 features:
Mean VH and Mean VV
→ Majority voting

Ets Linotte →

Building removal

7. Follow-up - Open Issues

- Sentinel data:
  - Co-registration?
  - Cloud cover is too severe?
- Feature extraction:
  - How many features?
    → other spectral indexes (BI, BI2, CI, SAVI …)
    → spatial textures
    → coherence (available on Terrascope?)
  - How to merge them?
- RDS:
  - Too small → hard to detect changes, displacement
  - Too big → by averaging we might lose small changes

  → segmentation?
- Validation:
  - Orthophotos only once per year → Pleiades

7. Segmentation - IBA

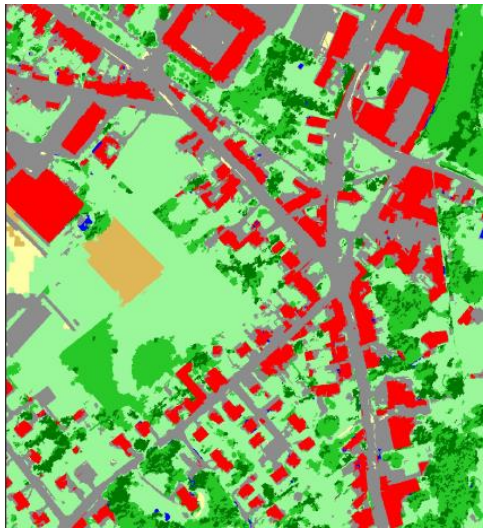
- Object segmentation
- Buildings perimeters of the RDS

2016

2018

7. Segmentation - WALOUS

- Object segmentation
- “WALlonie Occupation et Utilisation du Sol”
  - Land Cover / Land Use automatic cartography
  - Spatial accuracy 1 m (intermediate product 25 cm)
  - Sources: Orthophotos 2018, DSM > DEM 2018 (Gembloux), PICC, IGN, SIGEC, Masque Forestier (Gembloux)
  - UCL-ULB-ISSeP
  - Funded by SPW-SG-DGEO et SPW-ARNE



7. Segmentation - PICC

- Object segmentation
- “Projet Informatique de Cartographie Continue”
  - Digital cartographic reference for the whole Wallonia
  - Spatial accuracy less than 25 cm
  - Identifiable elements:
    - Buildings
    - Land use (trees, sports fields ...)
    - Parking

7. PICC

- Will be tested as reference for image segmentation to pre-isolate the different classes
  - Example of the SAR 62096_F_051 “Maison des Espagnols”

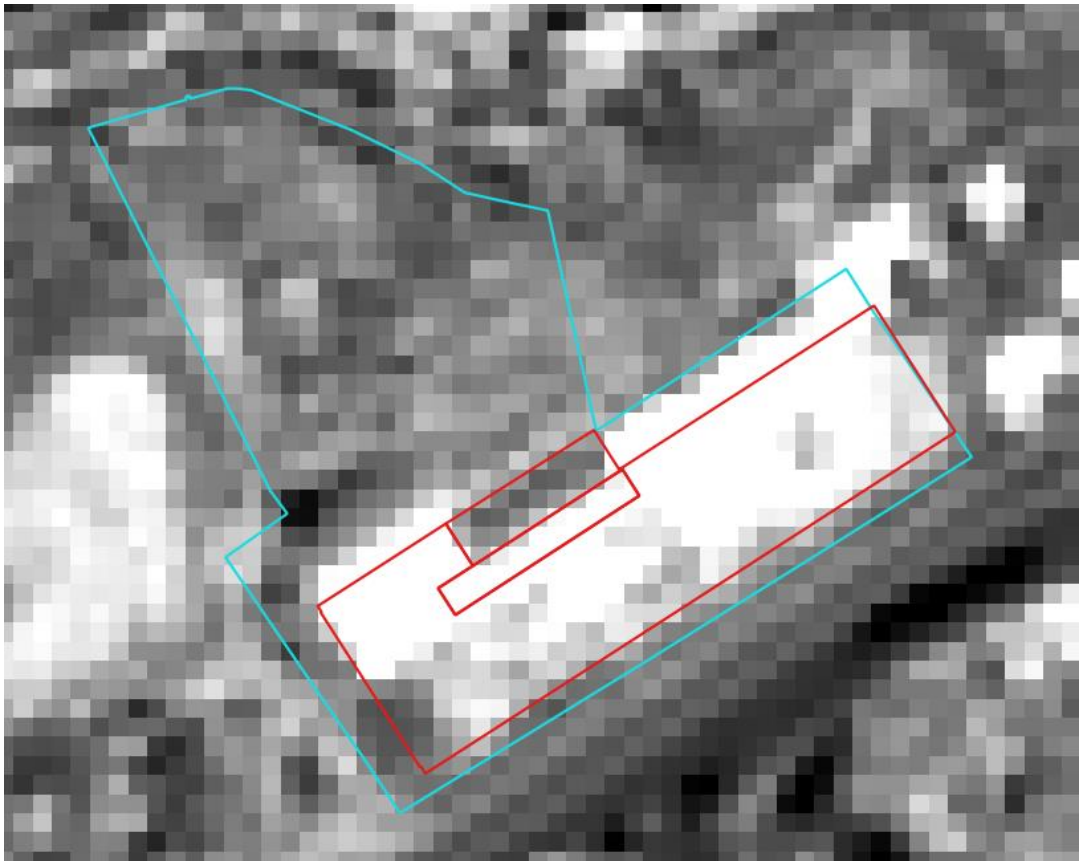
2016

PICC

2018

7. PICC – Sentinel-2

- Exemple of combinaison of BI2 index (2016-2018 difference) if used with segmentation (PICC)



Ortho-photos 2016

Ortho-photos 2018

7. Pleiades

- Potential issue : less Pleiades than expected and poor image quality
- Potential solution: increase our priority by increasing the area?
  - Example of Charleroi, 4 images instead of 9 in 2019 (1X/month):

20190203 20190226 20190401 20190729





Wallonie
territoire
SPW
ISSeP
belspo
Thank You