Creating Wallonia's new very high resolution land cover maps: combining GRASS GIS OBIA and OTB pixel-based results

FOSS4G-BE 2019

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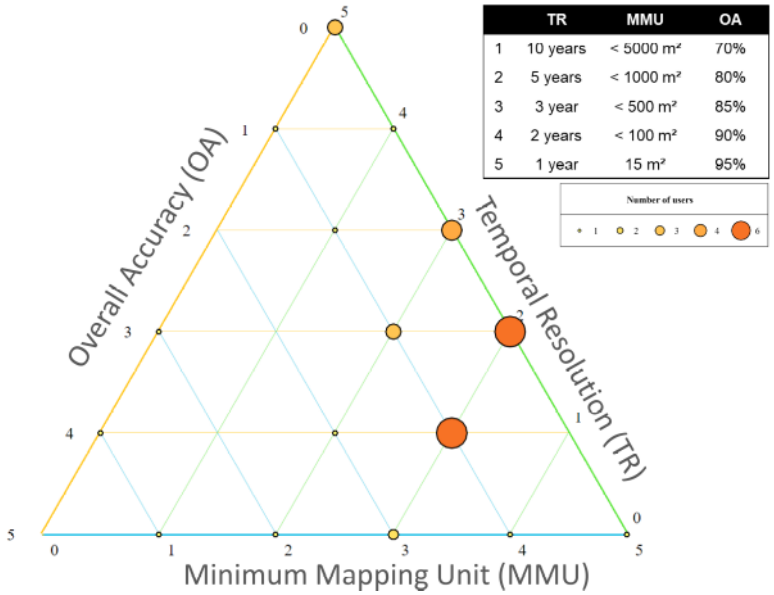
Context : Project

- Need for new land cover and land use maps of Wallonia
- Desire of the administration to obtain not only products, but methods
- Method should be open, reproducible and easily understandable by the administration
- Different existing research projects of the participating universities provided elements of methods
- Results have to be compliant both with user needs and with EU INSPIRE directive

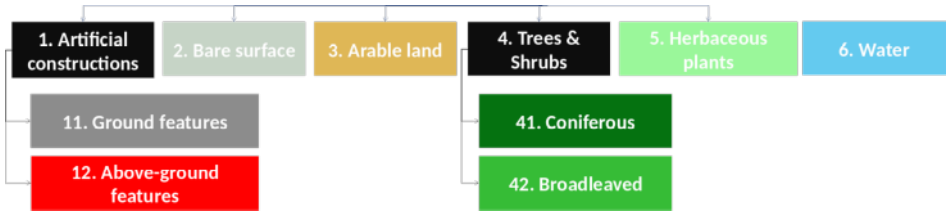
Objectives



	TR	MMU	OA
1	10 years	< 5000 m²	70%
2	5 years	< 1000 m²	80%
3	3 year	< 500 m²	85%
4	2 years	< 100 m²	90%
5	1 year	15 m²	95%

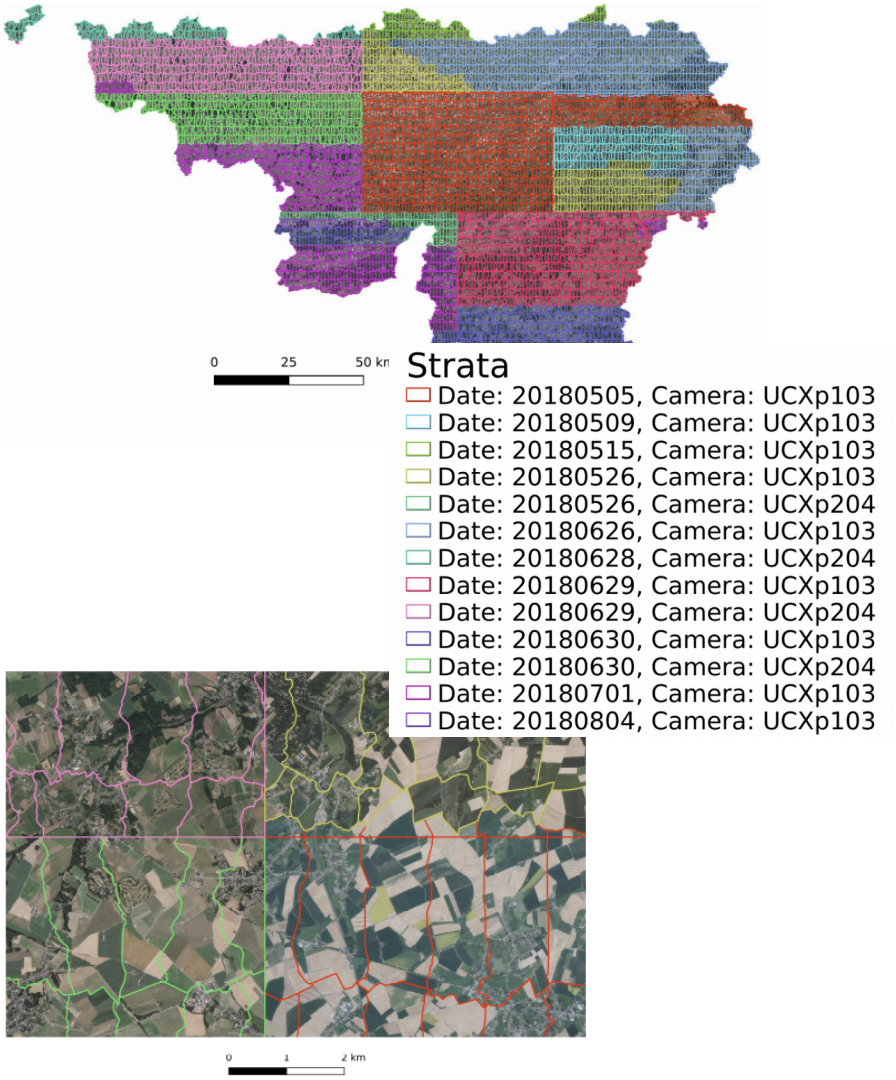
Compromises between objectives as preferred by users

- Intense interaction with potential users to define needs and specifications
- Work on defining :
  - Legend
  - Temporal resolution
  - Overall accuracy threshold
  - Minimum mapping unit
- Current results of process :
  - OA : 85 %
  - MMU : 15m2
  - Update frequency : 3-5 years



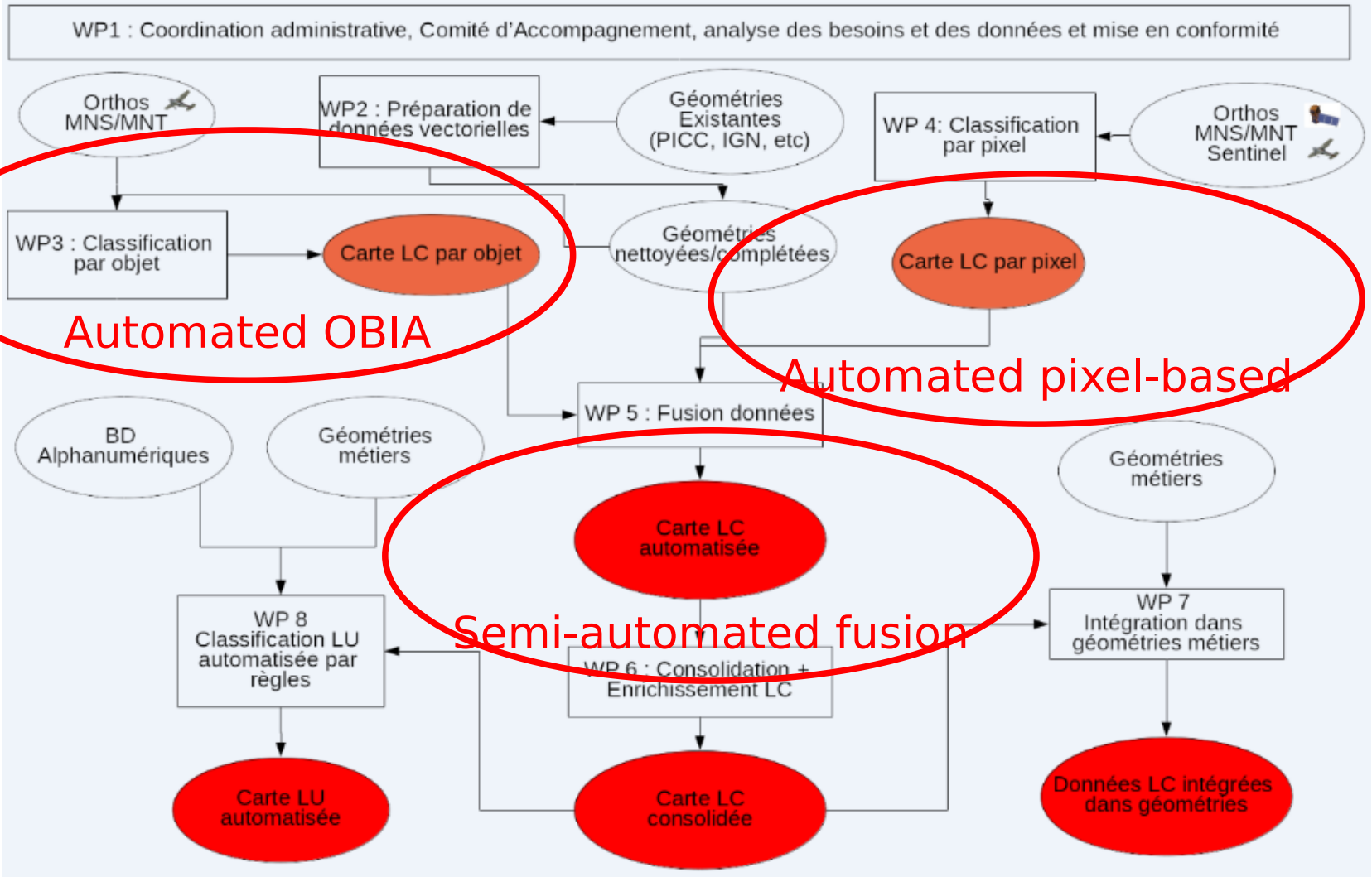
Proposed land cover legend

Data

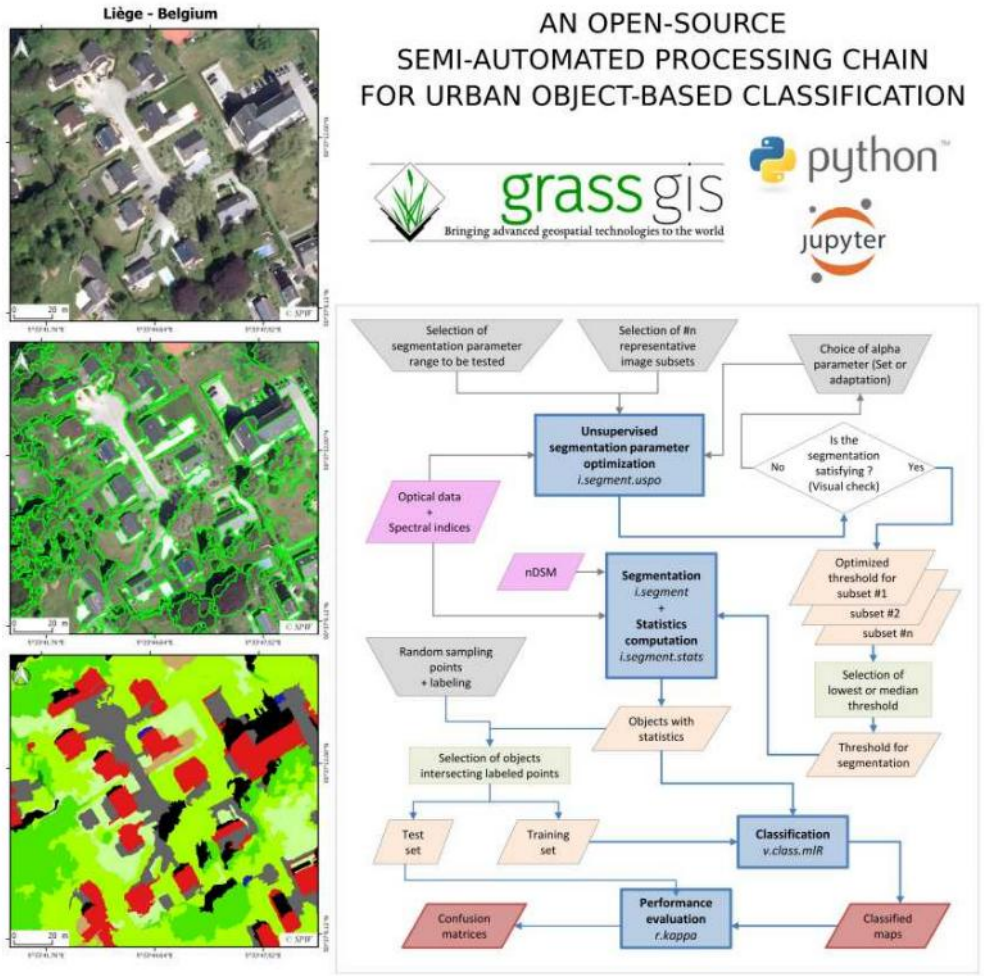


- 25cm orthophotos (RGB + NIR)
  - 2018
  - photomosaic from images taken during different flights
  - stratification by different dates and cameras
- nDSM (height layer) derived from the orthophotos
- Auxiliary vector data (buildings, roads, waterways, forests, agricultural fields)
  - Not always up to date
  - Not easily usable (e.g. roads only as axes, not polygons)
- Total size of dataset ~ 2.5TB

Method


WP1 : Coordination administrative, Comité d'Accompagnement, analyse des besoins et des données et mise en conformité
Orthos MNS/MNT
WP2 : Préparation de données vectorielles
Géométries Existantes (PICC, IGN, etc)
WP 4: Classification par pixel
Orthos MNS/MNT Sentinel
WP3 : Classification par objet
Carte LC par objet
Géométries nettoyées/complétées
Carte LC par pixel
Automated OBIA
Automated pixel-based
WP 5 : Fusion données
BD Alphanumériques
Géométries métiers
Carte LC automatisée
Géométries métiers
Semi-automated fusion
WP 8 Classification LU automatisée par règles
WP 6 : Consolidation + Enrichissement LC
WP 7 Intégration dans géométries métiers
Carte LU automatisée
Carte LC consolidée
Données LC intégrées dans géométries

Method : OBIA



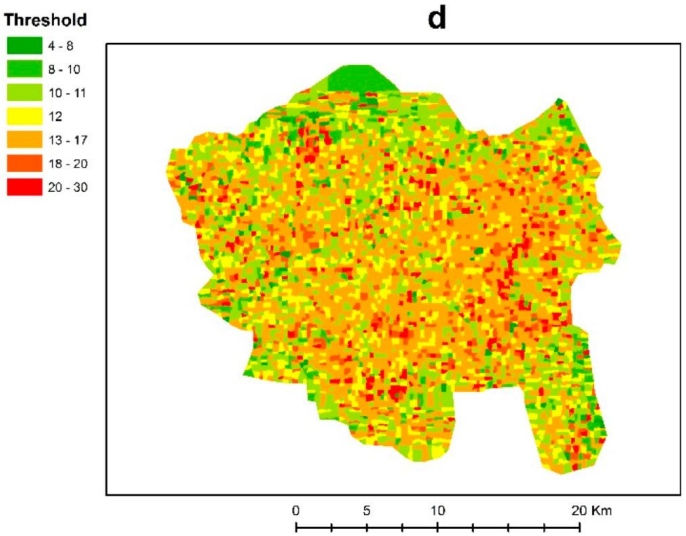
source : Grippa et al (2017), Remote Sensing, https://dx.doi.org/10.3390/rs9040358

- GRASS GIS
- Scripts using GRASS GIS Python API
- R for machine learning classifier
- HPC application (shared ICT Services Centre, Université Libre de Bruxelles) : highly parallelized

Method : OBIA

Cutlines

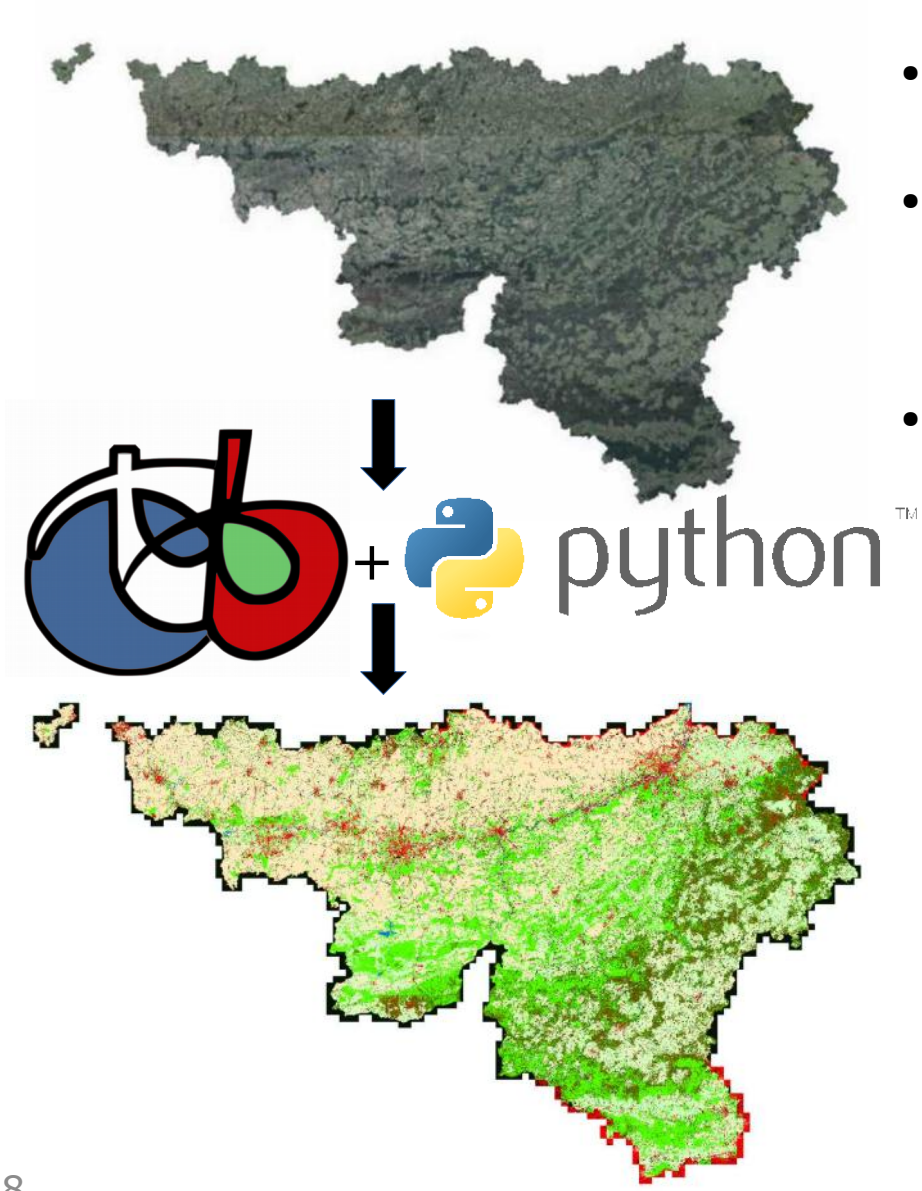
Spatial variation of « optimal » segmentation parameter



source : Georganos et al (2018), Remote Sensing, https://doi.org/10.3390/rs10091440

- Cutlines for tile creation (*i.cutlines*)
- Superpixels for acceleration (*i.superpixels.slic*)
- Spatially partitioned unsupervised parameter optimisation (*i.segment.uspo*)
- Automatic selection of training objects based on existing databases
- Random forest classifier (*v.class.mlR*)

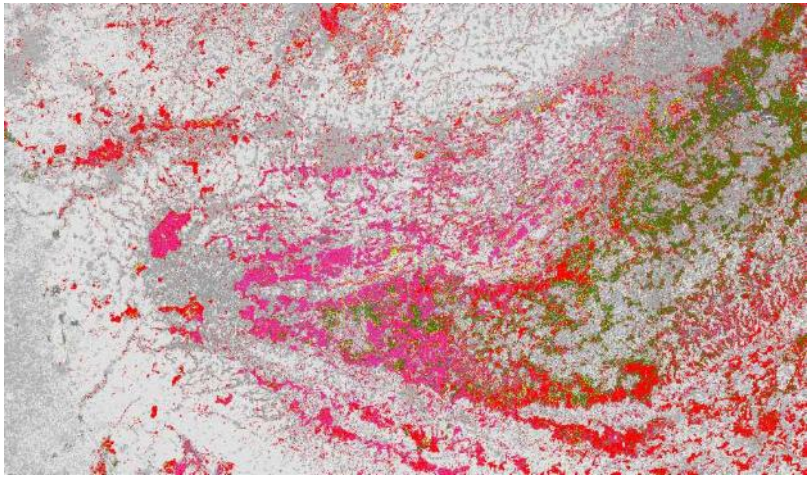
Method : Pixel-based



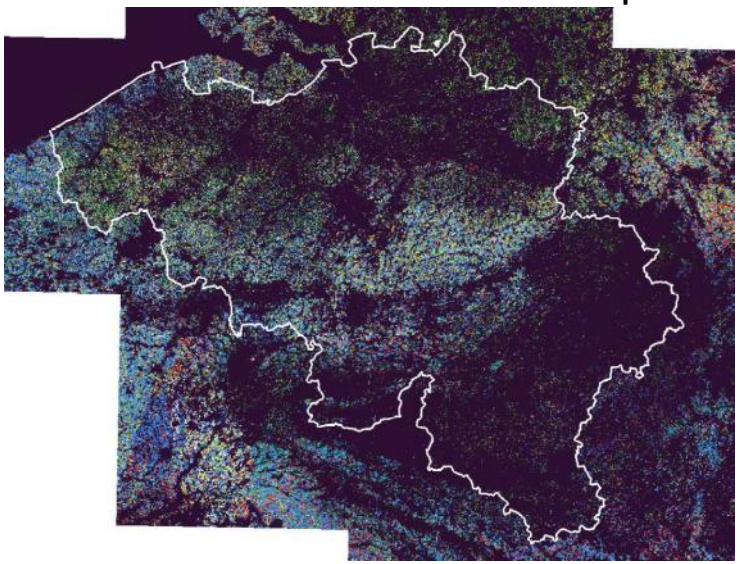
- One main product based on the 25 cm orthophotos + nDSM
- Tools
  - Orfeo ToolBox (OTB) + Python
  - HPC (CÉCI, F.R.S.-FNRS Grant No. 2.5020.11 and Walloon Region)
- Main steps
  - Mean shift smoothing (Comaniciu and Meer 2002)
  - Reference dataset compiled from existing 2m LC map, nDSM and shadows derived from nDSM
  - Reference dataset eroded using multiclass mathematical morphology operator (Radoux et al. 2014).
  - Classification with height as a priori probability

Method : Pixel-based

Sentinel-2, Forest classification



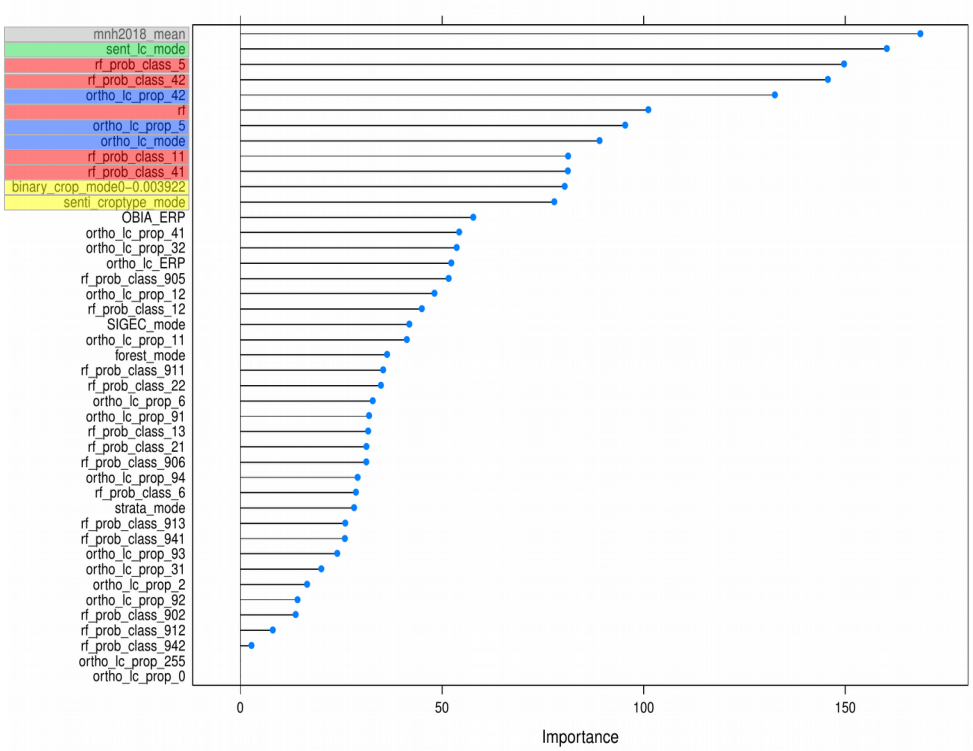
SEN2AGRI : black = no crops



- Other pixel-based layers using Sentinel-2 :
  - Landcover based on two dates allowing discrimination of vegetation(e.g. deciduous vs coniferous)
  - Multitemporal SEN2AGRI toolbox product (http://www.esa-sen2agri.org/) for crop identification

Method : Fusion

OBIA | Pixel 0.25m | Pixel 10m | Pixel Crop | Aux

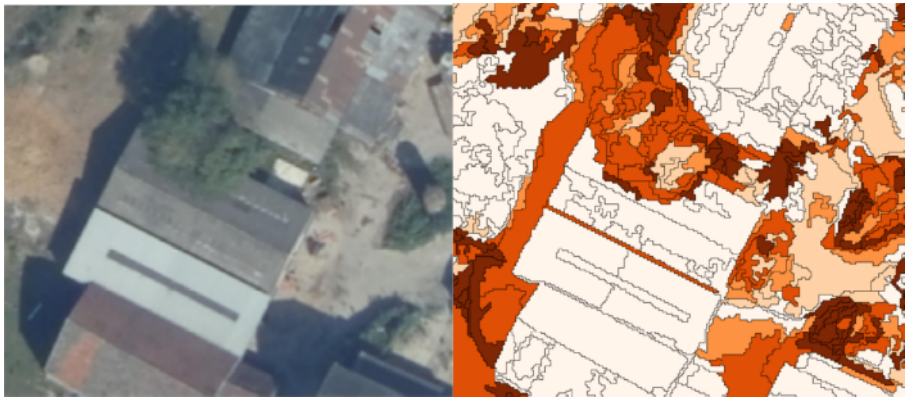


Final automated classification

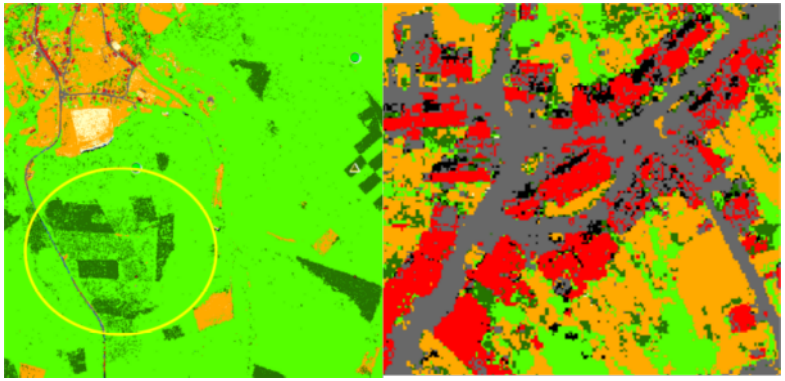
- Combine strengths of each method
- Input :
  - Classes and class probabilities
  - Some auxiliary data
- Test of three methods
  - Pixel-based
    - Rule-based (as benchmark, but difficult to generalize)
    - Dempster-Shafer
  - Object-based :
    - Machine learning (Random Forest)

Results : Classification

OBIA : Sharp building edges, but over-segmentation for vegetation
=> higher uncertainty (darker color)



Per pixel : Salt-and-pepper effect and object delineation issues



- Each classification has its strengths...
  - OBIA : shapes of objects (e.g. urban) + smoothness
  - Per-pixel : vegetation
- ... but also weaknesses :
  - OBIA : oversegmentation for vegetation
  - Per-pixel : salt-and-pepper effect, object delineation

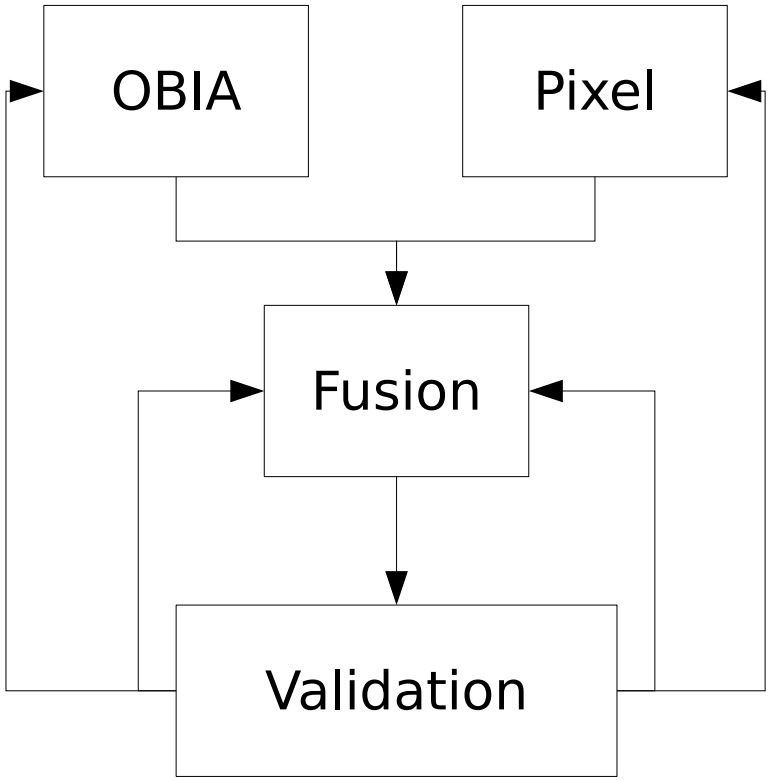
Results : Fusion

Object-based

Dempster-Shafer

- Fusion methods :
  - Object-based :
    - smoother with sharp edges
  - Dempster-Shafer :
    - difficulties with multiple resolutions
    - thematically sometimes better
- Difficulty with class « arable land » :
  - Multitemporal from Sentinel, so only available at 10m resolution
- Semi-automated approach OA : 0.87 (8 classes)
  - Will be improved with manual consolidation

Discussion



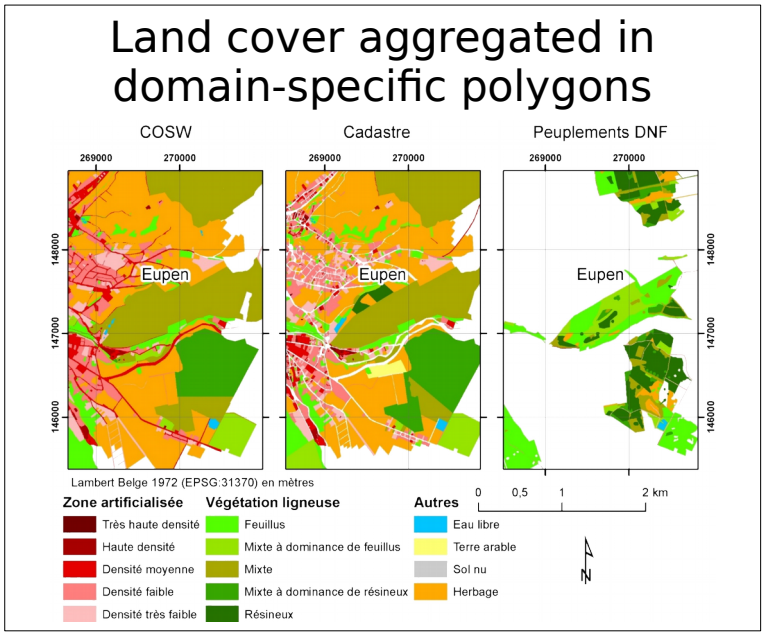
- Fusion provides qualitative improvement over individual classifications
- Object-based, machine learning approach seems most efficient
- Accuracy of the inputs into the fusion is major determinant of the quality of results
- => Iterative approach : back and forth between fusion and original classifications

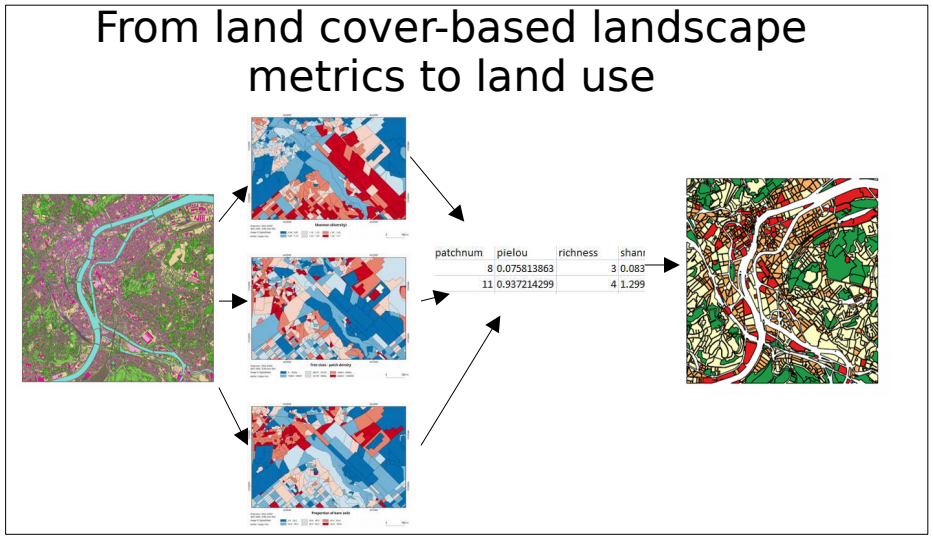
Contributions to FOSS4G

- Project has contributed to the development of FOSS tools
- A general heavy-duty real-life test of the GRASS GIS OBIA pipeline
- Enhancement of existing modules :
  - i.segment.uspo
  - i.segment.stats
  - i.cutlines
  - v.class.mlR
  - etc
- Development of new modules :
  - r.texture.tiled

OBIA HPC scripts available on github :
https://github.com/mlennert/WALOUS

Perspectives





- Finalization of entire automated approach
- Manual correction of land cover map => very high quality product
- Integrate LC information into
  - Domain-specific polygons
  - Automated process for land use mapping
- Products should be available as open data
- Future work :
  - Updating methodology
  - Use results as input for deep learning approach

Thank you for your attention!!!

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