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

- 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

Compromises between objectives as preferred by users

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

WP3: Classification par objet

Carte LC par objet

Géométries nettoyées/complétées

Carte LC par pixel

WP 5: Fusion données

BD Alphanumériques

Géométries métiers

WP 8: Classification LU automatisée par règles

Carte LU automatisée

Carte LC automatisée

WP 6: Consolidation + Enrichissement LC

Carte LC consolidée

WP 7: Intégration dans géométries métiers

Données LC intégrées dans géométries métiers

Automated OBIA

Automated pixel-based

Semi-automated fusion
Method: OBIA

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

Spatial variation of « optimal » segmentation parameter

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

- 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

- 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)

Final automated classification
Results: Classification

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 issues

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

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

- 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
- \( \Rightarrow \) 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
• 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!!!

contact@walous.be