Towards an operational land cover map production system from Sentinel-2 image time series

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Objectives

New challenges: High spatial and temporal resolution, global coverage, early crop mapping detection or large data volumes

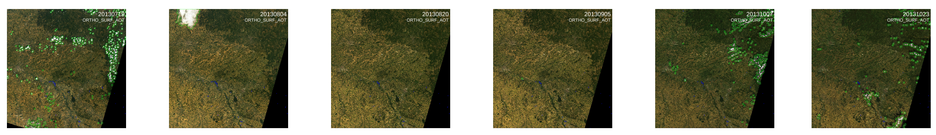
Our work : The construction of clear data flows for the implementation of land cover processing chains at different stages

- Pre-processing : from raw data to products.
- Data Analysis : the extraction of significant information.
- Classification : the study of algorithms capable of handling large data volumes.

Data pre-processing

Input data: Times series of Level 2A images produced with MACCS: ortho-rectified images in surface reflectance after atmospheric correction [1] with a cloud/cloud shadows/water/snow mask [2]

Example: Time series of L2A images with LANDSAT 8 (South of France):



2013-07-19 2013-08-04 2013-08-20 2013-09-05 2013-10-07 2013-10-23

Land cover over large geographic areas

Goal : Land cover supervised classification techniques requiring little or no human operation working on large geographical areas.

Challenges:

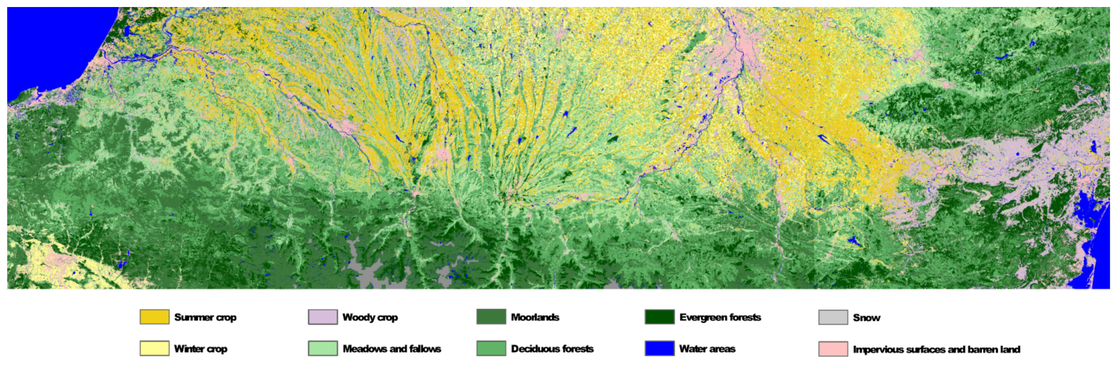
- Working with annual image times series, how to deal with clouds (temporal gaps), satellite passage borders or non permanent snow ?
- Different eco-climates across large areas results in high intra-class variability $\Longrightarrow$ pixels belonging to a same class have different spectro-temporal signatures.

Studied strategies:

- Gap interpolation strategies in order to work with high temporal frequency [4]
- Sustainable snow area handling [4]
- Training strategies taking into account the stratification of the landscape by geographic characteristics [3]
- The analysis of spectral evolution of land cover as a function of temperature degree-day and accumulated temperature information [4]

Our experiments:

- Landsat 5/7 times series (30m resolution)
- Automatic SVM supervised classification
- 500 samples per class ($< 0.1\%$ of the image)
- Tested over 3 million pixels ($3665 \times 3665 \times 6$)
- Computational cost:
  Training time : 0m 15.66s
  Classification time : 26m 09.23s



Class	Accuracy
Summer crops	80.23
Winter crops	80.79
Woody crops	81.90
Meadows	60.57
Moorlands	86.64
Deciduous	76.45
Evergreen	76.99
Water areas	79.93
Impervious/barren	80.58

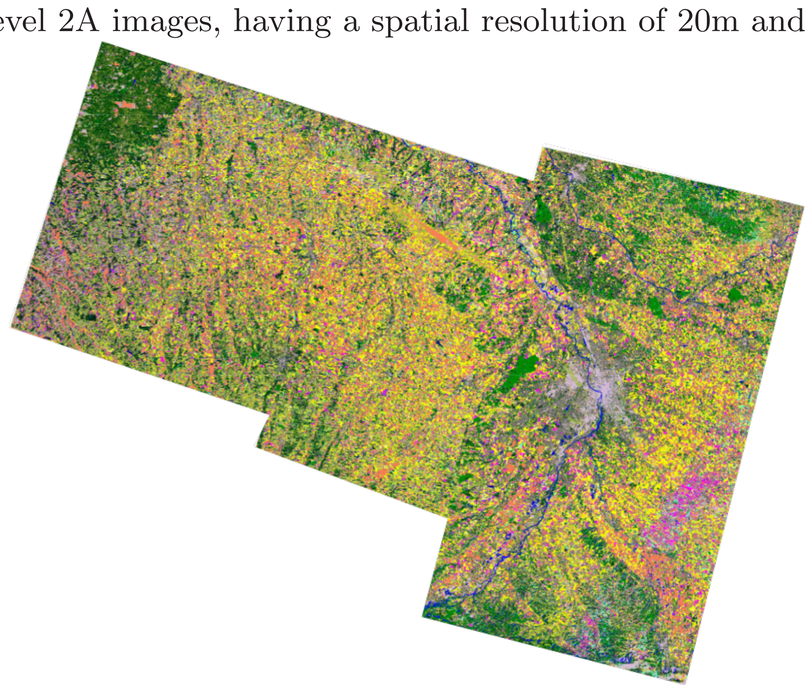
Global crop mapping

Goal: The production of EO algorithms for agriculture monitoring in order to prepare the exploitation of Sentinel-2 observations.

Challenges: To deal with different kinds of agricultural systems.

How to be ready: The exploitation of images coming from the Spot4 (Take5) experiment, which consists in turning Spot 4 during its last months into a simulator of time series such as those which are to be provided by the ESA Sentinel-2 mission. (Data available in `http://spirit.cnes.fr/take5/`)

Experiment: A supervised classification is performed on a large area in the South of France (covering $160 \times 300 km^2$). The geographic area contains more than 2000 crop fields. The used data is a Spot-4 image times series formed by 5 Level 2A images, having a spatial resolution of 20m and 4 spectral bands.



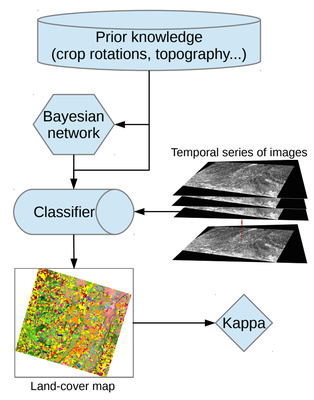
Class	Accuracy
Wheat	85.6
Rapeseed	96.6
Water	100
Eucalyptus	94.5
Hardwood	92.9
Wasteland	87.6
Gravel	94.5
Lake	96.3
Corn	94.5
Barley	85.1
Populus	90.2
Built-up	93.8
Resinous	98.0
Grassland	83.9
Mineral	100
Sunflower	90.6

Identification of crops in early stages

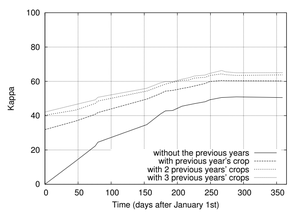
Challenges:

- High similarity between crop types at the early season
- The variability between the different sowing dates

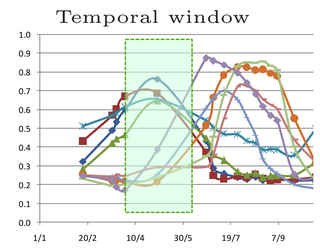
1st Strategy : Prior knowledge information is modeled by a Bayesian network to be used in the classification process [5]



Encouraging Results : The introduction of information about crop rotations increases dramatically the classification results at the first dates of the year.



2nd Strategy: Knowing the crop calendar, the most discriminative temporal window across the annual NDVI times series is studied.



Proposed Approach: A decision tree based on thresholds, computed at previous years, is applied on the temporal window formed by 3 images.

Results: A study is performed on 4 years by using Formosat-2 data (spatial resolution 8m).

Year	Prod. Acc.	User. Acc
2006	97.12	87.73
2007	95.17	92.19
2009	98.32	92.55
2010	96.72	90.42

Future work

- The use of these techniques for the exploitation of future data such as Sentinel-2, Landsat-8 or Venμs.
- The intelligent exploitation of the high temporal resolution coming from new satellites data.
- Handling large data volumes in "Real-Time".
- The **S2-Agri Esa project** releasing open source processing software for Sentinel-2: production of Global dynamic crop masks and Global Land Cover maps.

sentinel-2

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References

[1] O.Hagolle, G.Dedieu et al. Correction of aerosol effects on multi-temporal images acquired with constant viewing angles: Application to Formosat-2 images. Remote Sensing of Environment, 2008, 112 (4): 1689-1701.

[2] O.Hagolle, M.Huc et al. A multi-temporal method for cloud detection, applied to FORMOSAT-2, VENUS, LANDSAT and SENTINEL-2 images. Remote Sensing of Environment, 2010, 114 (8): 1747-1755.

[3] I.Rodes, J.Inglada et al. Sampling strategies for unsupervised classification of multitemporal high resolution optical images over very large areas, Proceedings of IGARSS 2012: pp.6761-6764

[4] I.Rodes, J.Inglada et al. Non-linear time sampling driven by surface temperature for the monitoring of vegetated areas using multi- and hyper-temporal satellite image time series, Proceedings of IGARSS 2013: pp.6761-6764

[5] J.Osman, J.Inglada et al. Crop mapping by supervised classification of high resolution optical image time series using prior knowledge about crop rotation and topography, Proceedings of IGARSS,2013.