Large scale automatic land cover map production with Sentinel-2 image time series: current status and outlooks

J. Inglada^{1,2}, M. Arias¹, A. Vincent¹, B. Tardy^{1,2}, D. Morin¹, J. Michel²



[2016-05-11 Wed]



Outline

1 Fully automatic land cover map production

2 Examples

3 How we do it

4 Conclusion

G GEEE



Fully automatic land cover map production

 Up-to-date land cover maps are a crucial asset for many research works and operational applications



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 - automatic, robust and reliable methods,
 - able to efficiently exploit all available data.
 - ► The so-called *washing machine*.



The Theia OSO Land Cover product

- In the frame of the French Theia Land Data Centre
 - http://www.theia-land.fr/
- Fully automatic production of LC maps at the national scale:
 - 20 class nomenclature;
 - 20 m resolution;
 - yearly updated;
 - delivered at the latest 3 months after the reference period.



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 - reference data for automatic model calibration and automatic product validation.
- Compatible with and complementary to existing products:
 - CLC is less fresh, has lower temporal and spatial resolution, but has more classes (44);
 - Urban Atlas is very detailed but limited in spatial extent and not frequently updated;
 - High Resolution Lavers: guality. status?



- Non goal
 - Produce a hand-crafted



The map or the process?

Non goal

Produce a hand-crafted, extremely semantically rich



The map or the process?

Non goal

▶ Produce a hand-crafted, extremely semantically rich, 99% accurate land cover map



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- Constraints
 - ► Full automation: for efficiency and reproducibility.
 - ▶ No hand-made or class/landscape/region specific rules: open to nomenclature changes.
 - · Computationally efficient processing: short delivery delay, reprocessing when specs change.



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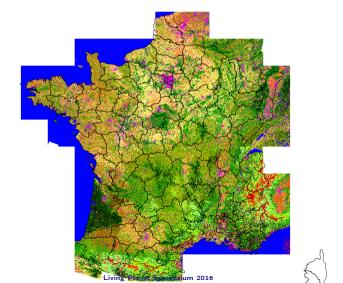
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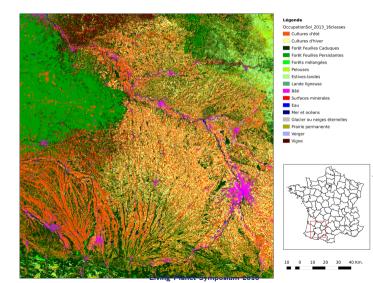
Product prototypes using Landsat8



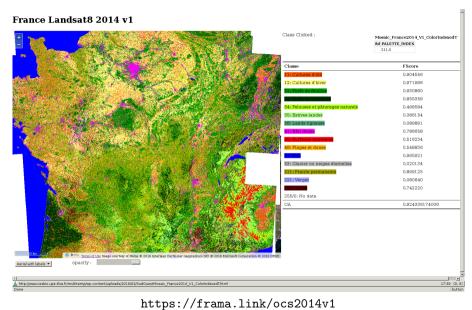


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Product prototypes using Landsat8









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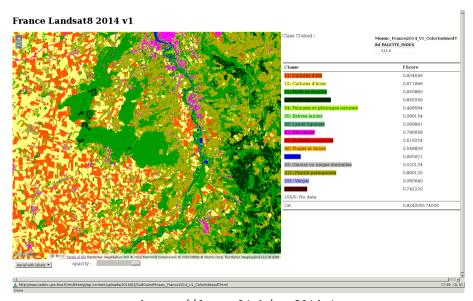
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The iota2 processing chain

- Free software implementation available for download and contributions
 - Phttps://frama.link/iota2

¹Glue code for GDAL/OGR and Orfeo Toolbox Applications ²OTB-based custom modules IPC scheduling J. Inglada et al.

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The iota2 processing chain

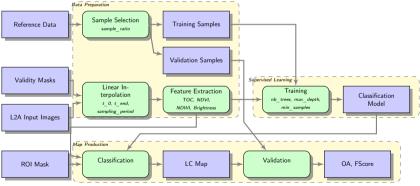
- Free software implementation available for download and contributions
 - Land Link/iota2
- HPC cluster or classical workstation
- Total Physical Source Lines of Code (SLOC)=11,382

Language	SLOC	
python ¹	8476	(74.47%)
c++ ²	2044	(17.96%)
unix shell ³	858	(7.54%)
other	4	(0.04%)

¹Glue code for GDAL/OGR and Orfeo Toolbox Applications ²OTB-based custom modules FRID IPC scheduling J. Inglada et al.

Kernel of the processing chain





Particularities of the approach

- ► Fully automatic, no operator
 - Supervised classification.



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- All available images are used
 - no date selection;
 - ▶ no scene elimination because of cloud cover: 90% of clouds is 10% of clear pixels.



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 - OK, a week if you don't have a 100 node HPC cluster!
 - and some optimisations are on the way;
 - allows for easy benchmarking and evaluation.



Scaling up

- Homogeneous acquisition dates
 - several orbits needed for a large territory;
 - gaps due to cloud cover;
 - time series used as classification features.



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- Spatial stratification, tiling?
 - data volume;
 - intra-class variability, landscape variability.



Scaling up

- Homogeneous acquisition dates
 - several orbits needed for a large territory;
 - gaps due to cloud cover;
 - time series used as classification features.
- Spatial stratification, tiling?
 - data volume;
 - intra-class variability, landscape variability.
- Reference data availability
 - spatial distribution;
 - outdated samples;
 - quality of the reference data (label noise).



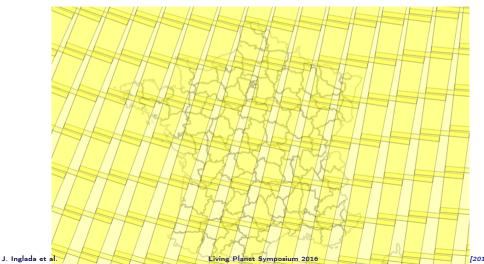
► The area to map





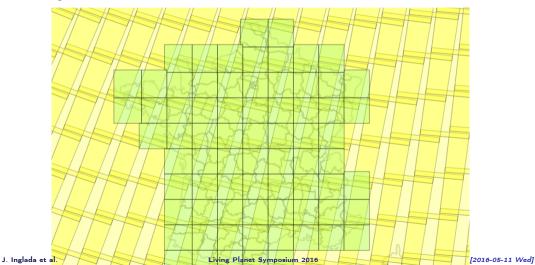
Image acquisitions: each orbit has different dates

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Data storage: tiles for convenience

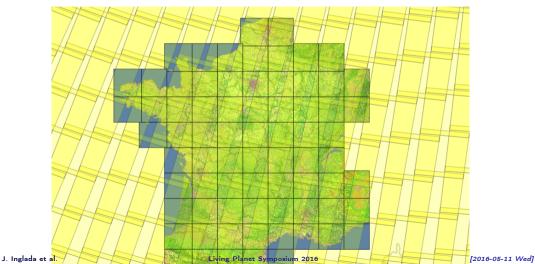
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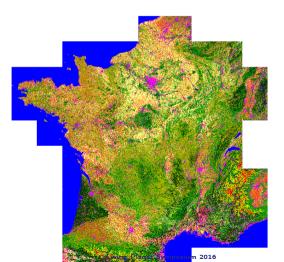
The map: continuity and homogeneity

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The map: continuity and homogeneity





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Site	OA	OA	
	original	resampled	p-value
Argentina	0.904 ± 0.026	0.893 ± 0.028	0.120
Belgium	0.816 ± 0.001	0.816 ± 0.001	0.312
Burkina Faso	0.522 ± 0.018	0.503 ± 0.018	0.122
China	0.927 ± 0.010	0.911 ± 0.031	0.193
France	0.904 ± 0.004	0.905 ± 0.004	0.770
Madagascar	0.501 ± 0.058	0.498 ± 0.070	0.818
Morocco	0.876 ± 0.004	0.875 ± 0.009	0.771
Pakistan	0.727 ± 0.035	0.723 ± 0.036	0.684
Russia	0.665 ± 0.019	0.665 ± 0.019	0.947
South Africa	0.907 ± 0.011	0.894 ± 0.015	0.023
Ukraine	0.740 ± 0.025	0.724 ± 0.024	0.019
US-Maricopa	0.911 ± 0.006	0.911 ± 0.006	0.939



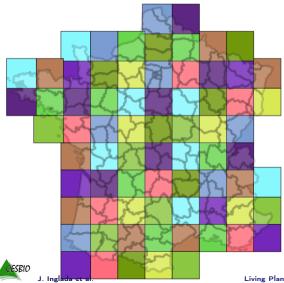
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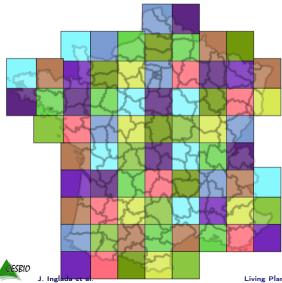


Speeding up the classification

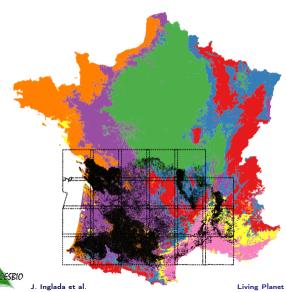


- ► A different classifier per group of tiles
 - allows for parallel learning.

Speeding up the classification



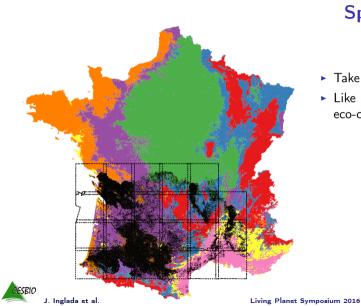
- A different classifier per group of tiles
 - allows for parallel learning.
- Classification step
 - classifier fusion for robustness and spatial homogeneity.



Spatial stratification

Take into account intra-class variability.

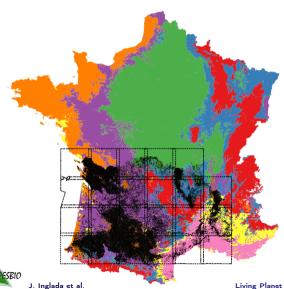
How we do it



Spatial stratification

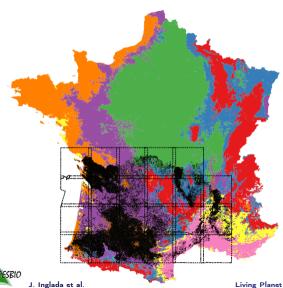
- Take into account intra-class variability.
- Like processing per tiles, but split per eco-climatic area.

How we do it



Spatial stratification

- Take into account intra-class variability.
- Like processing per tiles, but split per eco-climatic area.
- Several strategies for distributed classifier fusion are available
 - majority voting;
 - confidence map voting.



Spatial stratification

- Take into account intra-class variability.
- Like processing per tiles, but split per eco-climatic area.
- Several strategies for distributed classifier fusion are available
 - majority voting;
 - confidence map voting.
- No improvement noticed so far
 - the Random Forest classifier already generates sub-classes;
 - may be useful when reference data is really scarce.

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- Wrong! There are lots of data
 - CLC, topographic DBs, LPIS, OpenStreetMap, etc.



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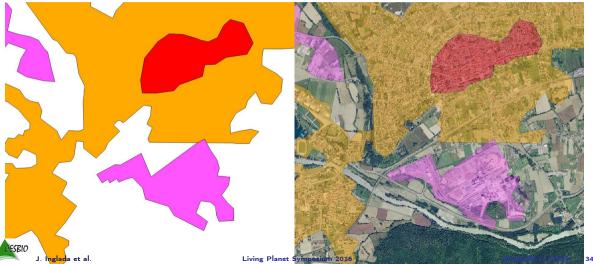
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 - CLC, topographic DBs, LPIS, OpenStreetMap, etc.
- The problem is
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- Automatic tools to merge existing data bases.
- Classifiers with high tolerance to label noise.



CLC polygons: minimum mapping unit too large



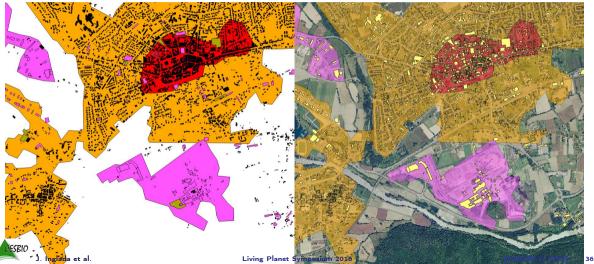
Topographic DB: different LC semantics, but spatially accurate

. Inglada et al.

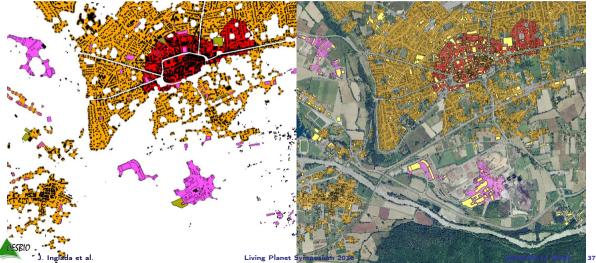
How we do it

Reference data cleaning

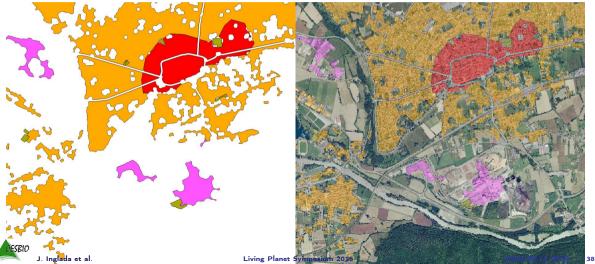
Fusing both data sources



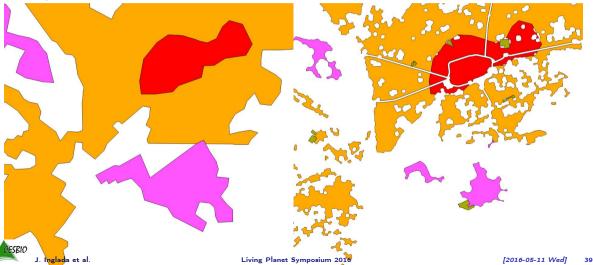
Spatial and semantic accuracy



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Improved reference data



• Reference data is expensive to collect.



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- Delay between collection and availability
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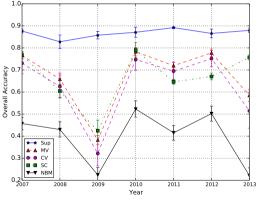


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- Use the wisdom of crowds
 - many inaccurate but decorrelated data sources may become good on average.



When no reference data is available (yet)

Example using other periods (images and reference data)

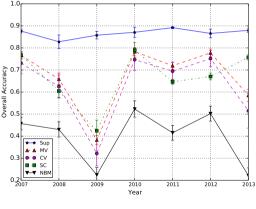


Supervised case (upper bound)



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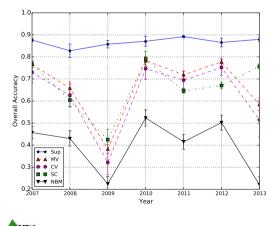


- Supervised case (upper bound)
- Best result with just one another year



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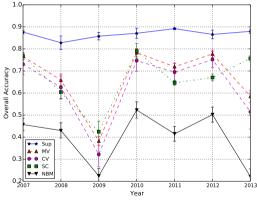


J. Inglada et al.

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- Best result with just one another year
- Using all other years and one single classifier
- Majority voting with one classifier per year
- Confidence-based fusion with one classifier per year



Other ongoing improvements

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- Multi-temporal image segmentation.
- Use of VHR optical data (SPOT6, Pléiades)
 - single date, used for object-based image analysis.



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A pragmatic approach to land cover mapping (nearly) ready for operational production at the national level



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 - this is much cheaper than launching a satellite!



Living Planet Symposium 2016

Q&A

- Get the slides: https://frama.link/inglada-landcover
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