PROGRAMME OF THE EUROPEAN UNION

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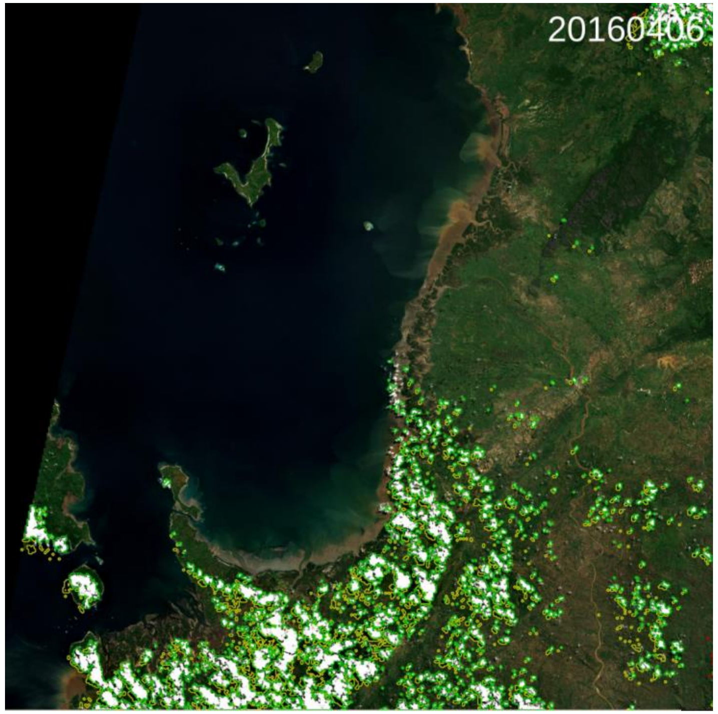
MAJA: State of the software 2023

AGENDA

1) INTRODUCTION
    - What is MAJA ?
2) Software performances
    - Assessing MAJA capabilities
3) Example of use (1): the SOCCROP indicator
    - MAJA for cloud detection
4) Example of use (2): the S2GMW project
    - MAJA for efficient cloud free L3 production
5) MAJA as a service
    - Integration to AWS Fargate
6) CONCLUSION and perspectives



What is MAJA ?

- **M**accs-**A**tcor **J**oint **A**lgorithm

- Atmospheric corrections and cloud detection for L2 generation
  → surface reflectances are estimated based on aerosol contents, cloud and shadow detection and various atmospheric effects
  → Can used CAMS data

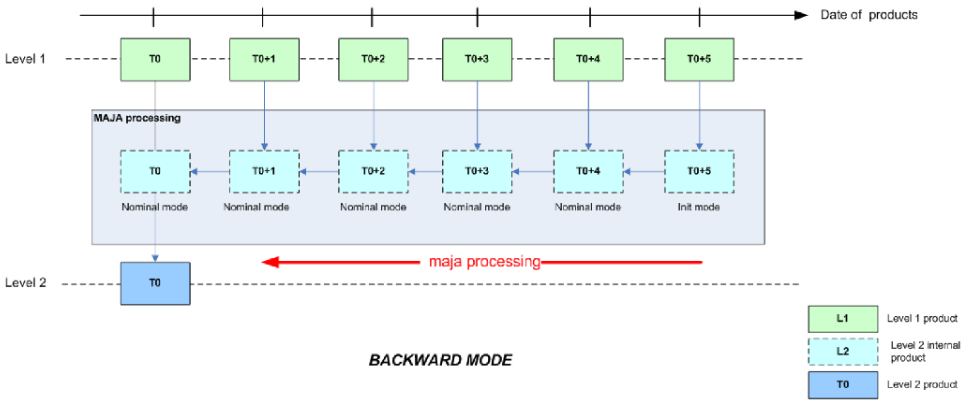
- Multi-sensor: **Sentinel 2**, Landsat, Venμs, SWH …

- Based on the Orfeo Toolbox: https://www.orfeo-toolbox.org/
  --> an image processing open-source library with state-of-the-art capabilities : optical / radar, multi-spectral, high resolution, terabyte scale

- Uses multi-temporal approach: optimal 8 products input ensures output quality

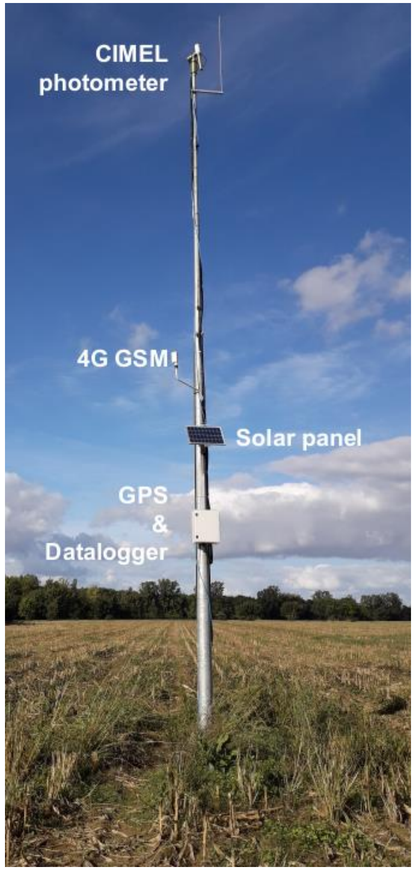
- Open source (Apache V2): https://gitlab.orfeo-toolbox.org/maja/maja

Orfeo ToolBox
Orfeo ToolBox is not a black box



MAJA : Software performance

Colin, J.; Hagolle, O.; Landier, L.; Coustance, S.; Kettig, P.; Meygret, A.; Osman, J.; Vermote, E. "Assessment of the Performance of the Atmospheric Correction Algorithm MAJA for Sentinel-2 Surface Reflectance Estimates. Remote Sens. 2023, 15, 2665. https://doi.org/10.3390/rs15102665



ROSAS site at FrLam, FR

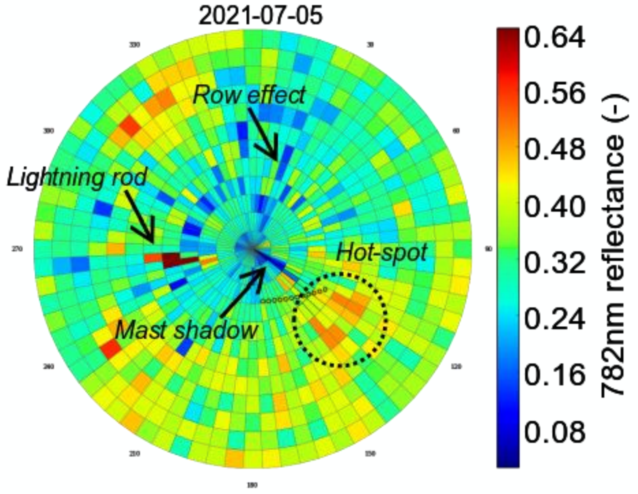
Continuous validation effort of MAJA Sentinel-2 surface reflectances, latest published in Colin et al. (2023) with comparisons:

- against the ~1.3 billion reference pixels of ACIX II
    - AERONET + 6SV based (no adjacency correction)
    - From Aug. 2017 to Sept. 2018
    - 127 locations worldwide

    => Good spatial sampling of indirect estimates within 12 months
- against measurements from the ROSAS network
    - Full in-situ characterization of surface BRDF using a 12 bands CIMEL radiometer
    - Up to 5 years of nearly continuous measures
    - 3 sites in France and Namibia

    => Good temporal sampling of direct measurements but limited land cover variability

Example of ROSAS BRDF @782nm acquired at FrLAM on July 2021



MAJA : Software performance

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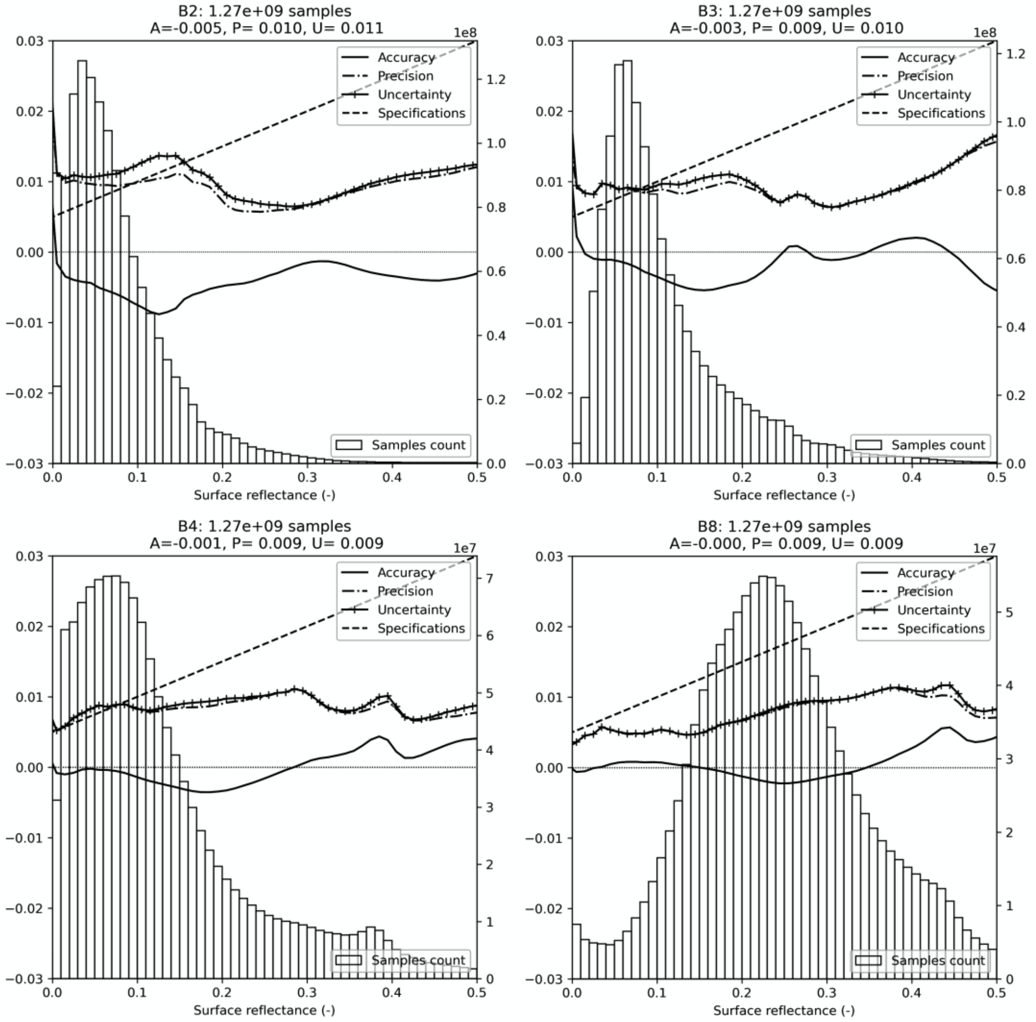
Stacked results of inter-comparison between AERONET-based reference and MAJA ground reflectances for 10 m resolution Sentinel-2 MSI band (all dates, all sites)



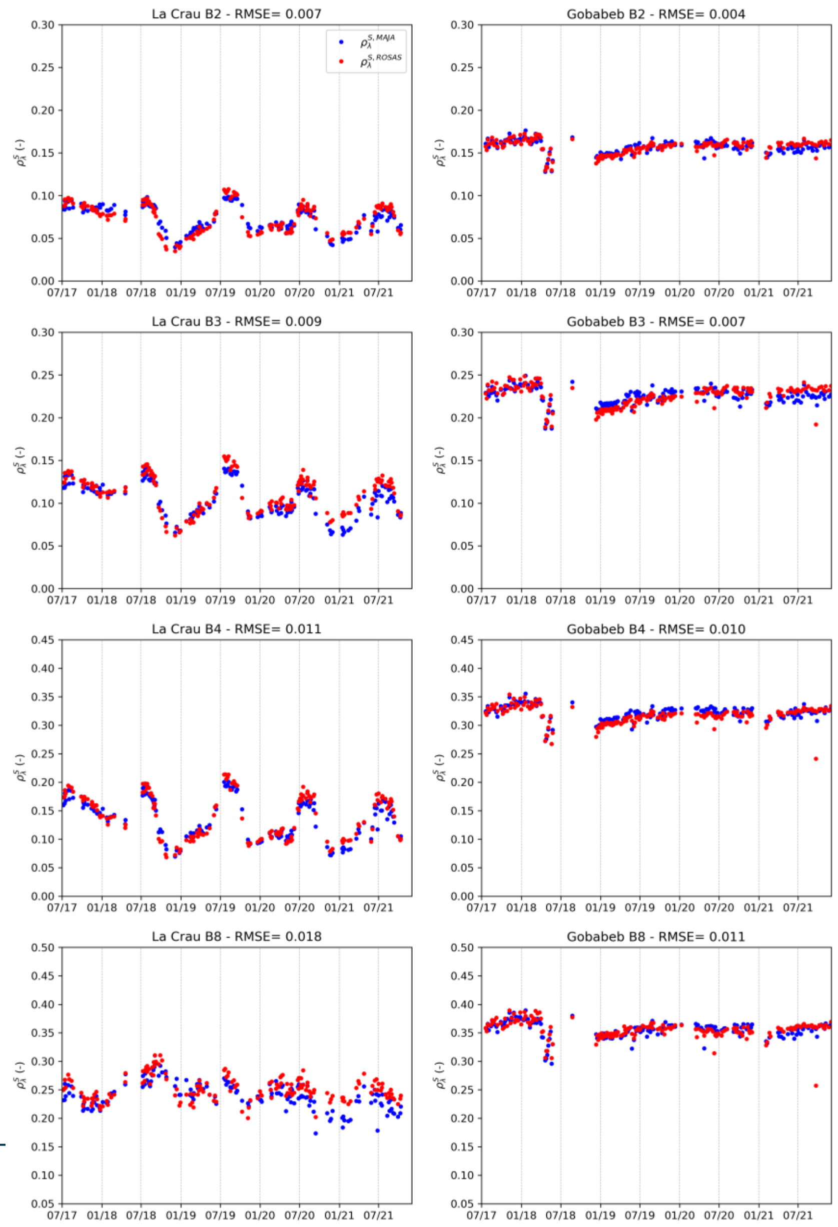
- MAJA Uncertainties against ACIX II surface reflectances range between 0.009 and 0.011 for Sentinel-2 bands 2, 3, 4 and 8 (right)
- Although ACIX-II gives a non-negligible advantage to 6SV-based AC processors, MAJA compares well to eg. LaSRC or Planet (below)

Uncertainties U $* 10^{-3}$ on the estimation of the Sentinel-2 surface reflectances

	ACcomp	ATCOR	FORCE	LaSRC	MAJA	Overland	Planet	SIAC
B2	15		8	10	11	18	8	12
B3	13		8	8	10	19	6	10
B4	12		6	7	9	21	6	11
B8A	14	30	5	7	9	31	8	17
B11	17	10	10	4	5	30	5	12
B12	19	6	7	4	4	20	7	13

MAJA : Software performance

Comparison of MAJA Sentinel-2 L2A (blue dots) and ROSAS (red dots) ground reflectances for sites La Crau (left) and Gobabeb (right) for Sentinel-2 bands 2, 3, 4, and 8 (top to bottom).



- Such comparisons account for both Sentinel-2 (3% on TOA reflectances), ROSAS (5% error budget) and MAJA errors;
- Same order of uncertainties as with ACIX for surface reflectances in the visible bands;
- Greater uncertainties when the S2 and CIMEL bands do not match spectrally (+ calibration issue for Fr-Lam);
- MAJA vs ROSAS uncertainties on AOD < 0.075;
- CAMS aerosols auxiliary data improve RMSEs on reflectance estimates by an order of 0.001 to 0.008, and on AOD up to 0.029

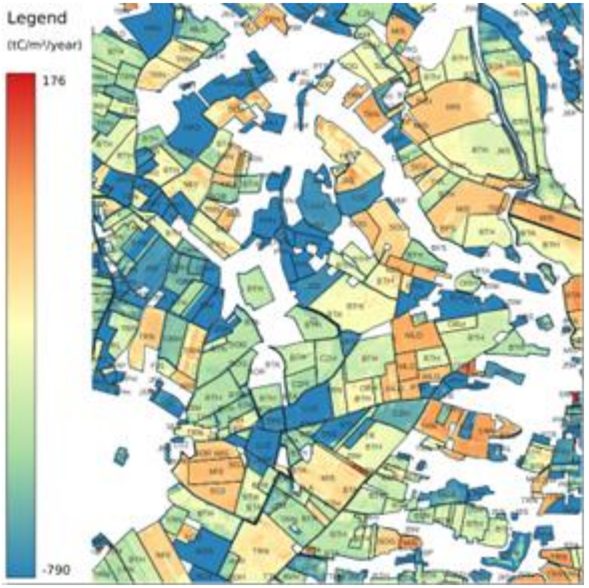
	La Crau		Gobabeb	
	Continental	CAMS	Continental	CAMS
AOD	0.074	0.045	0.070	0.067
B2 492 nm	0.009	0.007	0.007	0.004
B3 560 nm	0.015	0.009	0.011	0.007
B4 665 nm	0.015	0.011	0.011	0.010
B5 705 nm	0.018	0.013	0.014	0.010
B6 740 nm	0.021	0.015	0.013	0.011
B7 783 nm	0.022	0.016	0.014	0.011
B8 842 nm	0.023	0.018	0.014	0.011
B11 1.6 µm	0.017	0.016	0.018	0.021

RMSEs of MAJA vs ROSAS with the default “continental” mode and “CAMS” mode

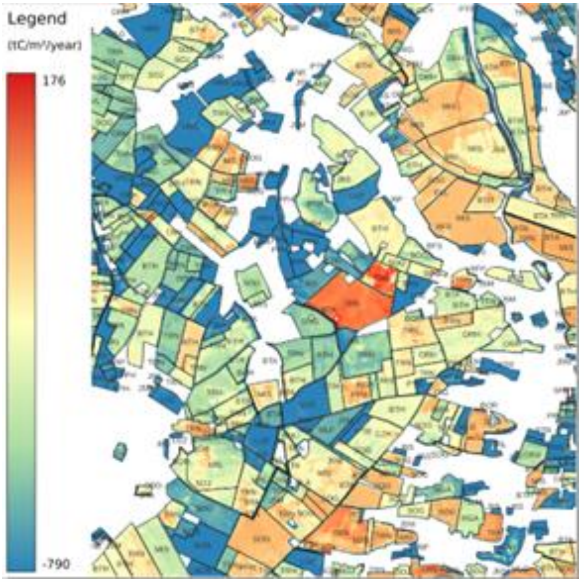
INRAe

Objectives:

- Quantifying carbon storage in soils by estimating the NDVI on a daily-basis from Sentinel 2 images (H2020 Niva project)
- Generating Carbon Index maps from L2A images
- Helping the farming community to manage crops more efficiently, maximizing yields and limiting diseases



2019 Net CO2 flow, precision 10m



2020 Net CO2 flow,

Carbon index as developed by INRAe :

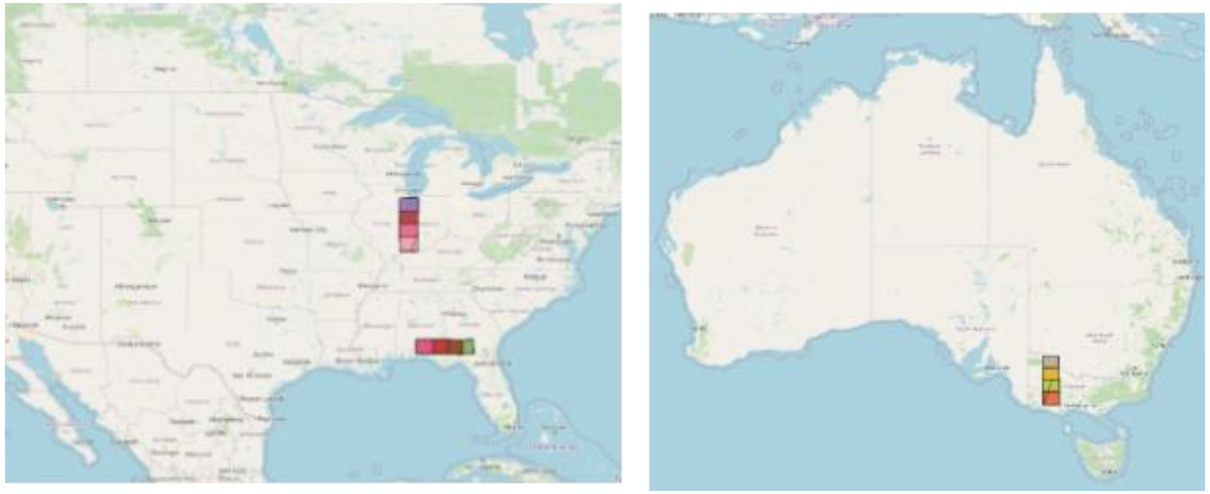
$$NEP = c * NGD + d*NAS$$

Where :
- NGD = days where NDVI >0.3
- NAS = days during which the soil respiration is potentially more active
- c and d = regression parameters

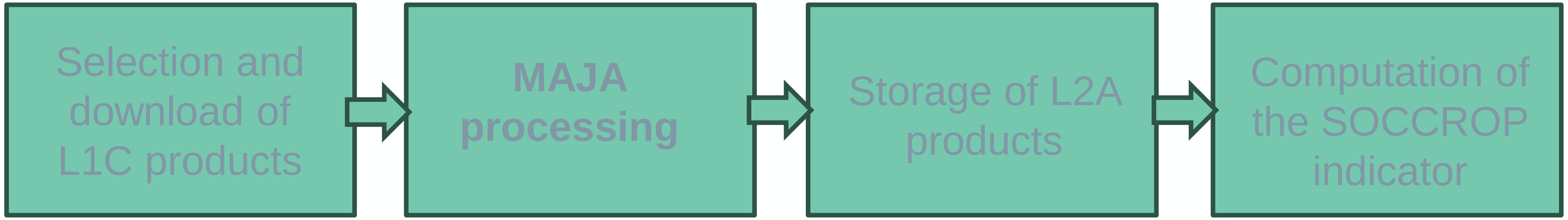
Example of application (1): SOCCROP

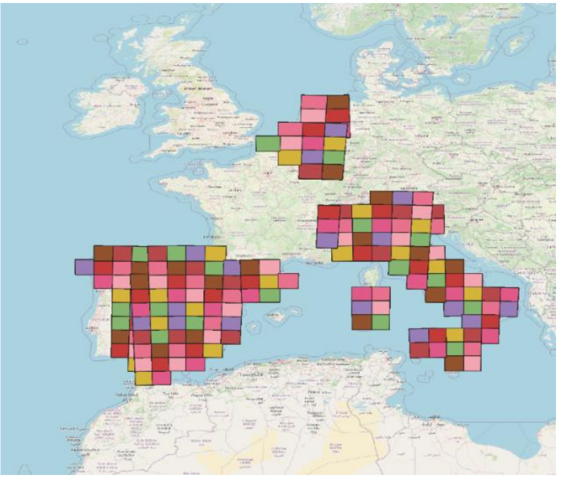
On cloud detection accuracy:

- Cloud detection accuracy has a strong impact on the final SOCCROP indicator
- **MAJA** was used because of the high precision of its cloud masks, due to its multi-temporal approach



Some of the L1C products uses in the map generation

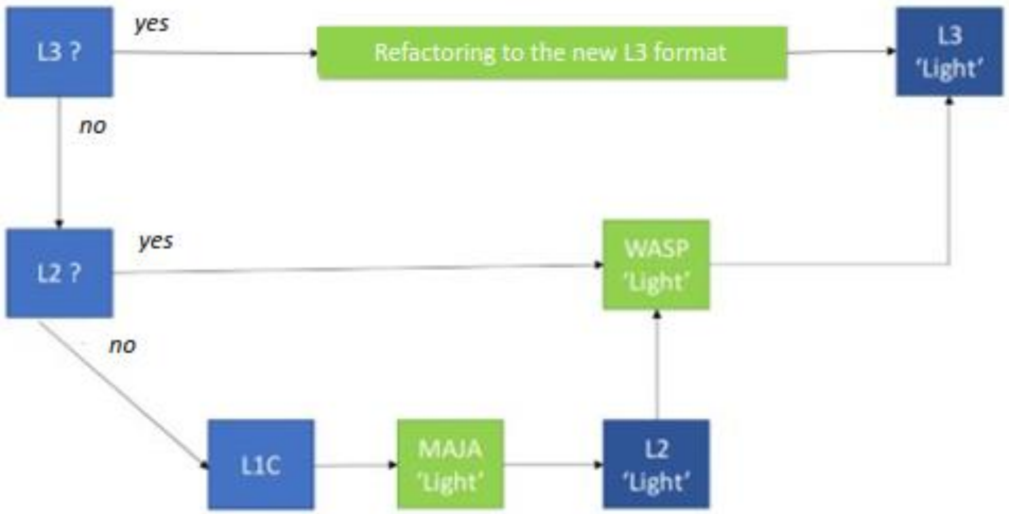


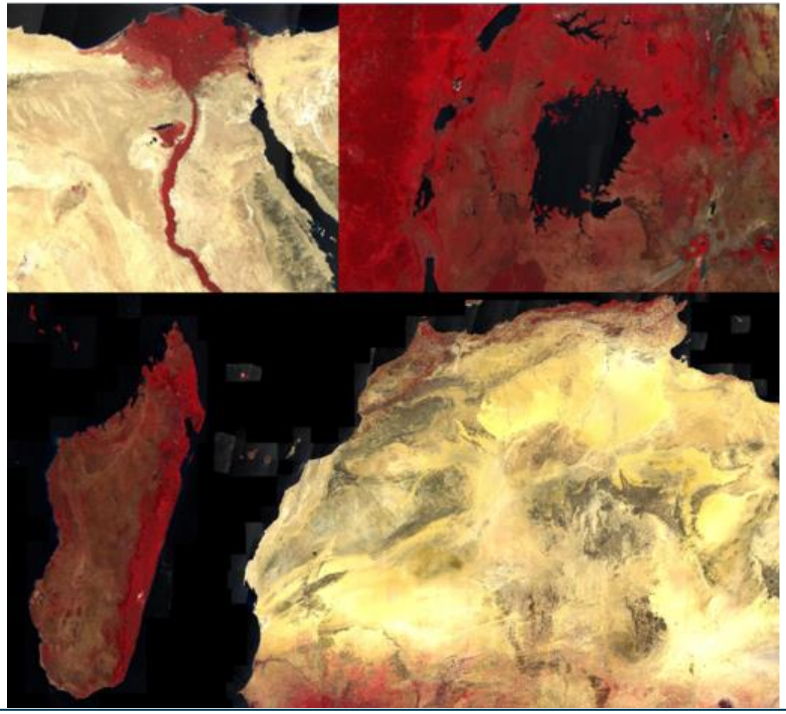


Example of application (2): S2GMW

Objectives:

- Generating world cover S2 cloud-free L3 synthesis, 1 per season
- Producing an operational tool, allowing coming MicroCarb mission (launch 2025) validation and future uses by CNES projects





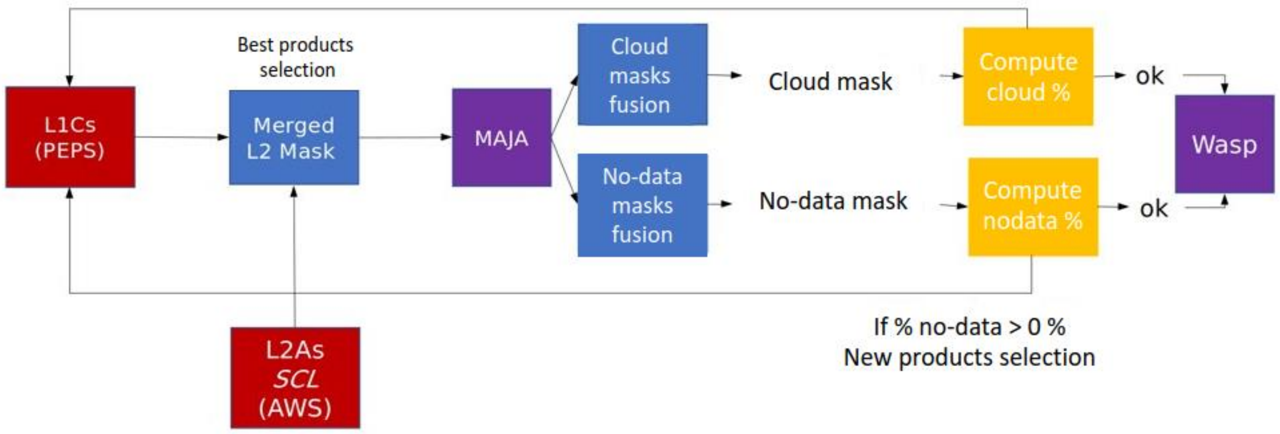
Strengths:

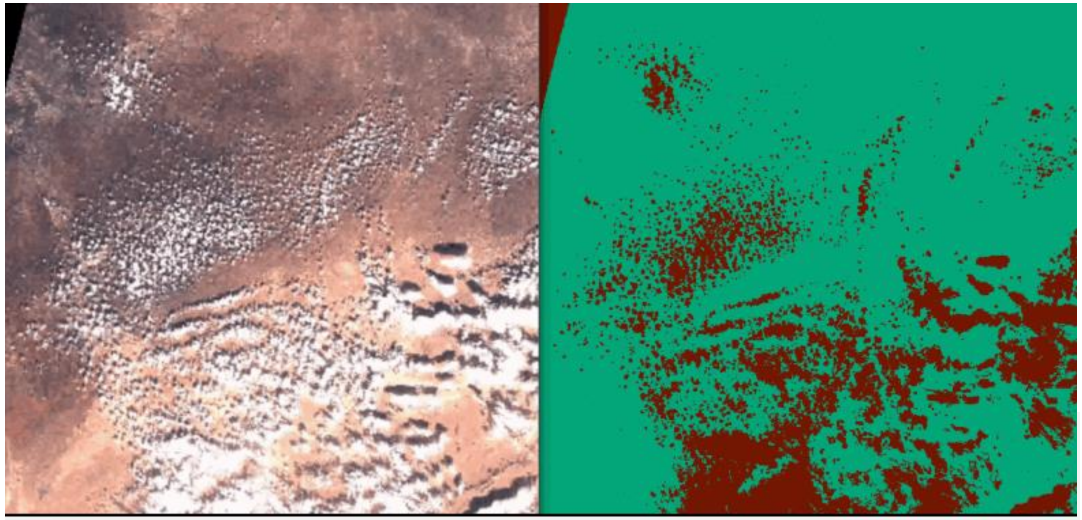
- Uses **MAJA** with time series to obtain minimal cloud coverage for the synthesis.
- Uses **MAJA** flexibility to create a new hybrid MUSCATE format, minimizing computing time and needed storage: 60m resolution and 7 bands only

S2GMW: Orchestrator

Steps:

- Check with EODAG the highest-level product available on each tile
- If L3 available, then refactoring to L3 Hybrid format
- If L2/L1C:
  - Selection of the 8 best products based on cloud and data coverage,
  - **MAJA** (if L1C) and WASP are then launched
  - If L3 with cloud pixel > 1% then restart the selection



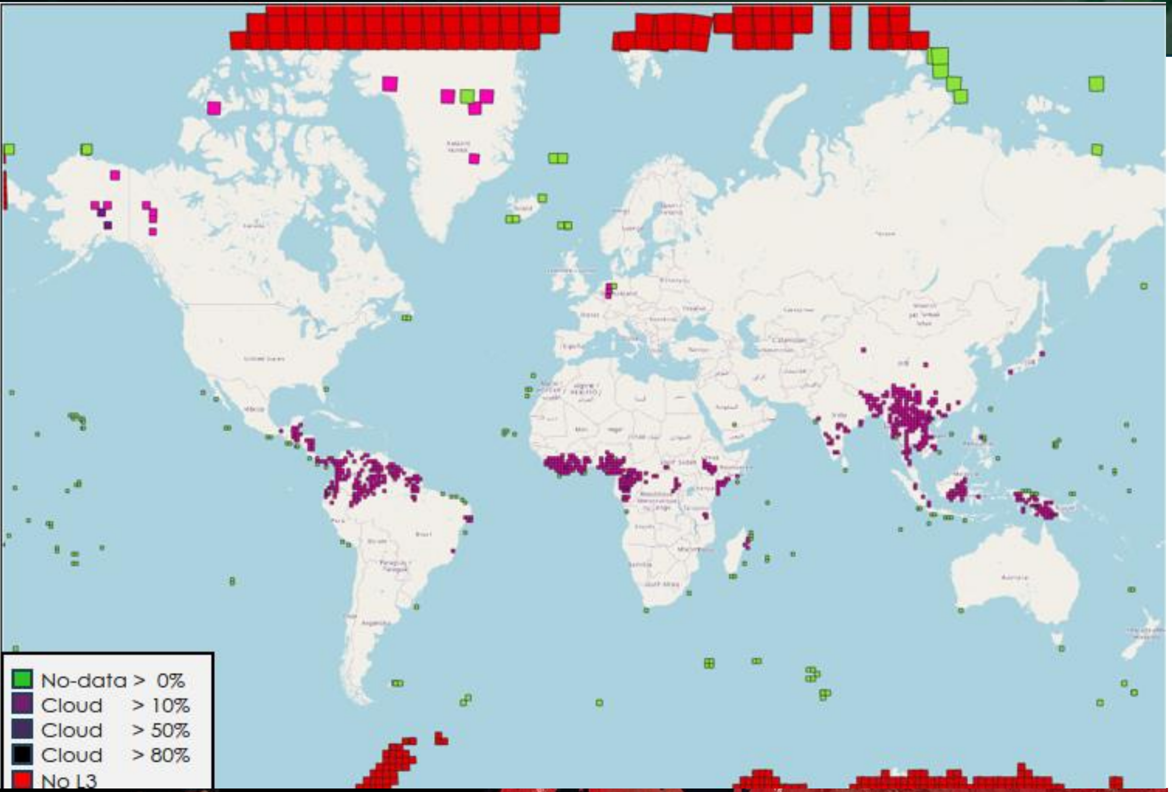


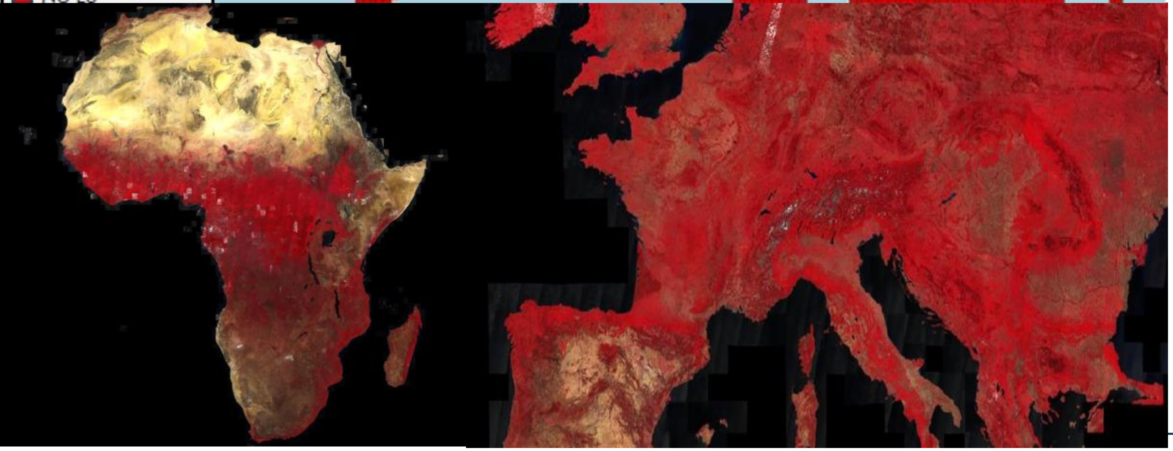
Coverage (ground)
Coverage gain by adding a product
No coverage (cloud or no-data)

Selection of the best products:

- Use of Sen2Cor's L2A cloud mask (AWS Sentinel-COG)
- Sort products based on availability on L1C provider (PEPS)
- Sort products based on cloud and no-data percentage
- Selection of the product based on the coverage gain compared to a coverage mask built sequentially

S2GMW: Production and World cover quality





Production information:

- Production of a world reference: 3 weeks (~18 000 tiles)
- Job of 4 cpu / 16Go RAM running on the HAL cluster (CNES)
- Batch of ~ 1000 tiles launched every day

Summer 2022 world coverage:

- Tiles produced: 17842
- Tiles with no-data > 0% : 182
- Tiles with cloud > 10% : 665
- Mean process time for one tile : 3h10
- Mean download time: 50min
- Mean MAJA time: 2h20

MAJA as a service

MAJA used for THEIA initiative thanks to the CNES MUSCATE Production center

How to use in other areas or for local configuration?

MAJA fully compatible with AWS Fargate solution:

- Allows running containers on demand and with minimal server configurations;
- Allows to focus on the application: MAJA with user-defined configurations, easy to use ;
- Allows efficient parallelization of MAJA processing over nodes

AWS Fargate

➡ Tests were run for the SOCCROP project: 1 year of L2A products could be generated in 3 days.

MAJA is fully compatible with cloud infrastructure for massive production

Conclusion

- MAJA is an **operational tool** used in many concrete **applications**
- MAJA is **public and free**, available to end-users as well for developers
- An effort is pursued to constantly improve MAJA **performances and sensor support**
- Next releases will focus on making MAJA more **flexible** and **easy-to-use** to adapt smoothly to future projects

https://gitlab.orfeo-toolbox.org/maja/maja

THANK YOU FOR YOUR ATTENTION ! :)