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# Sentinel-2 Based Empirical Indicator of Cropland Net Annual CO<sub>2</sub> Fluxes

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## Introduction

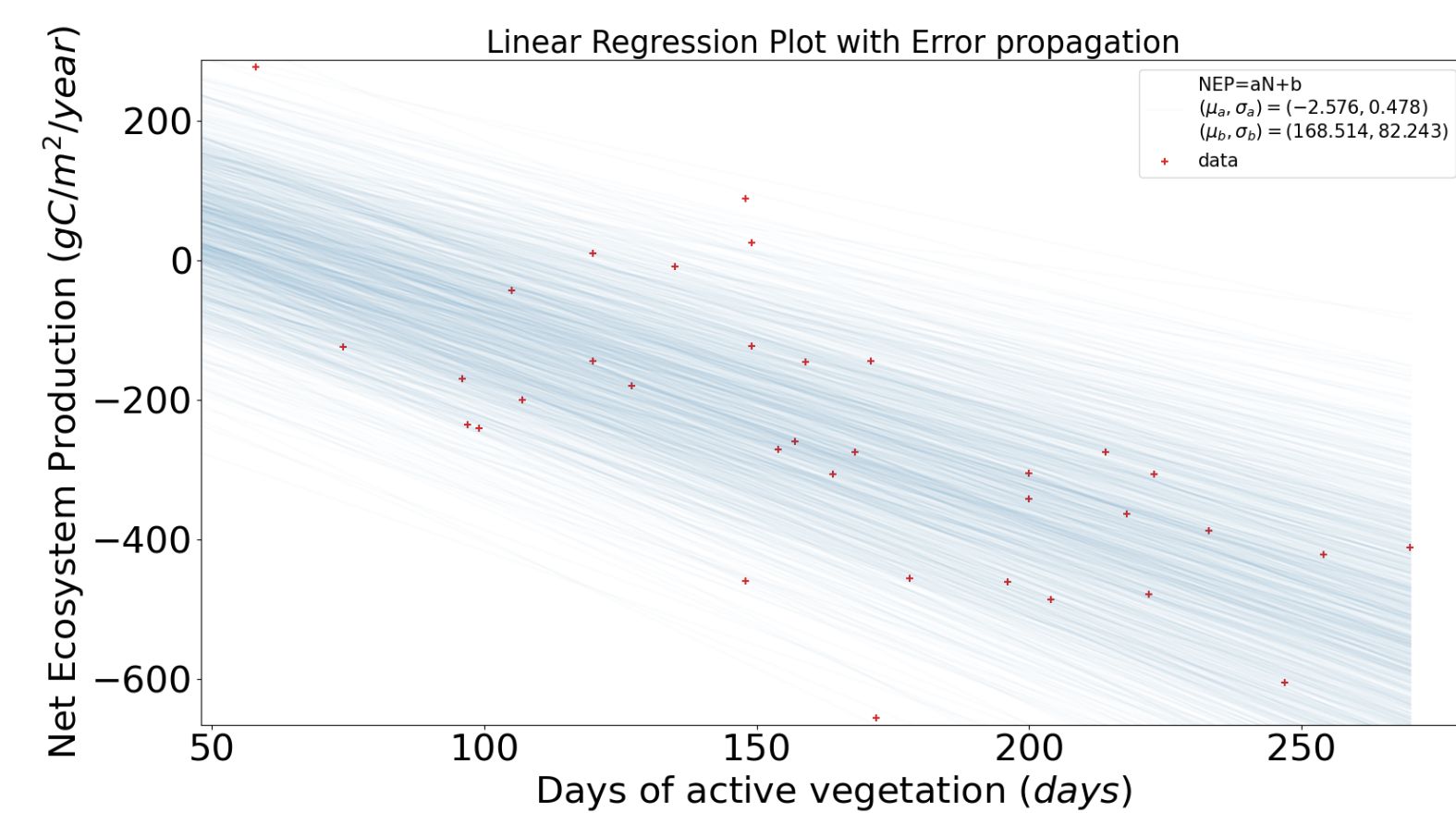
Agricultural carbon budget monitoring is a key task in a world undertaking global climate change. This is in this context that our team is part of the New IACS Vision in Action (NIVA) project that is funded by the European Commission<sup>[1]</sup>. The project aims to modernise Integrated Administration and Control System (IACS) by making efficient use of the wide range of data relevant for agriculture while reducing administrative burden for farmers, paying agencies and other stakeholders.

In the User Case 1b (UC1b) of this project, our team aims to develop several agro-environmental indicators prototypes that could be relevant for the future Common Agricultural Policy (CAP). The indicator presented in this poster assesses the net annual CO<sub>2</sub> fluxes of agricultural parcels. It is presented here in its simplest "Tier 1" form that estimates the net annual CO<sub>2</sub> fluxes indicator (CT1) directly from remote sensing imaging<sup>[2]</sup>. Note: the more advanced "Tier 2" approach combines net CO<sub>2</sub> flux with farmer's management data (organic amendments, amount of biomass exported at harvest) allowing the calculation of plot level carbon budgets. The most advanced "Tier 3" approach, based on physical modelization, will be presented in the talk scheduled at 8:45 in the A3.04.3 session.

## Empirical Indicator

### Methodology:

- The net annual CO<sub>2</sub> fluxes associated to an agricultural parcel is roughly proportional to the number of days of active vegetation that covers it during a cropping year<sup>[3,4]</sup>
- The number of days of active vegetation (NDAV) can be determined from remote sensing imaging. In this work, the normalized difference vegetation index (NDVI) calculated from Sentinel-2 time series is used. Active vegetation is assumed when  $NDVI > 0.3$  (bare soil).



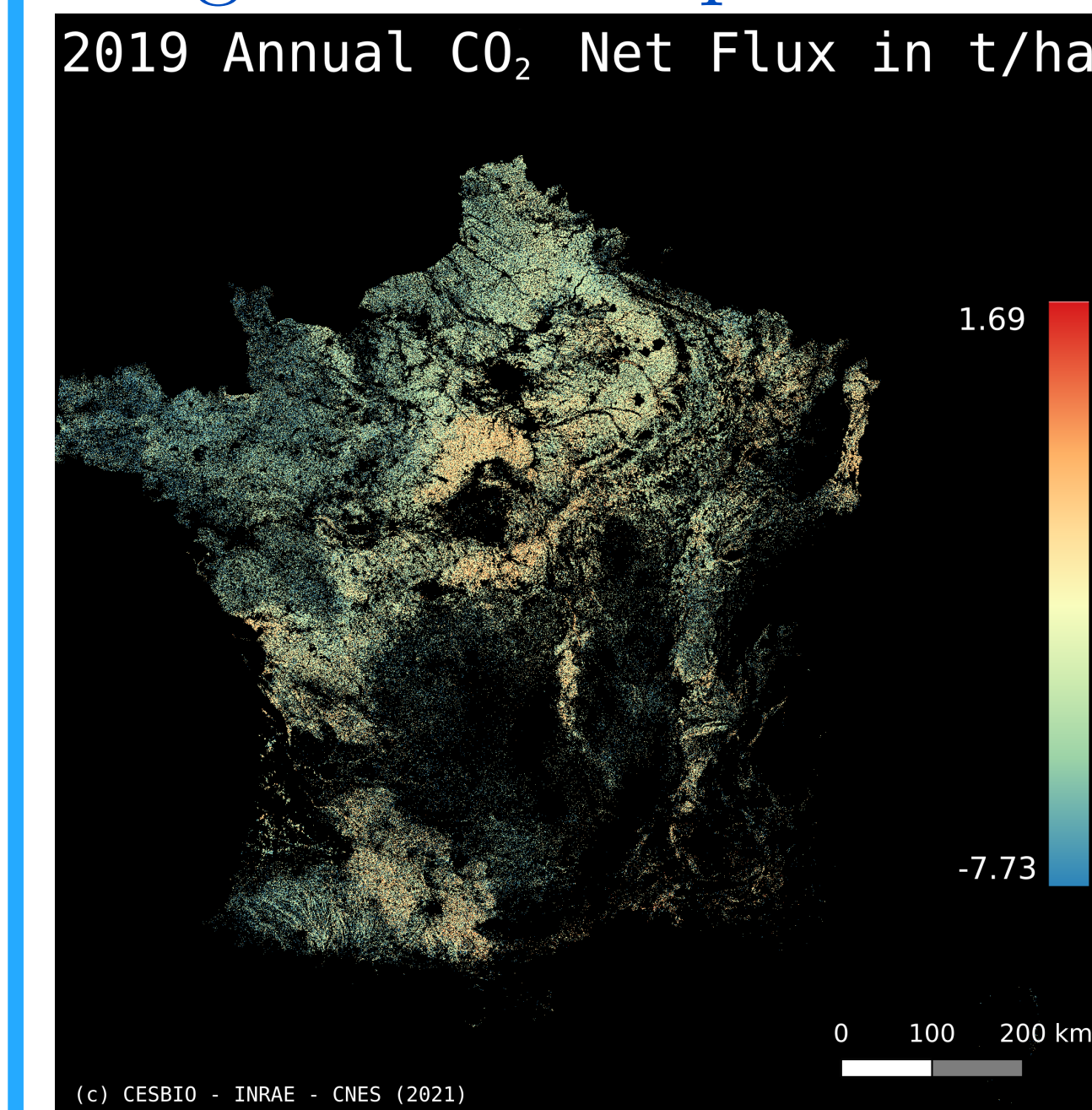
### Characteristics:

- Data driven model from 13 years of ICOS experimental data<sup>[5]</sup>
- Fitted to represents 17 different type of crops.
- Simplicity = Suitable for large scale calculations and complete characterization of the uncertainties

$$\sigma_{NEP} = \sqrt{\sigma_a^2 N^2 + \sigma_b^2 + a^2 \sigma_N^2} \quad (1)$$

## Maps for 2019

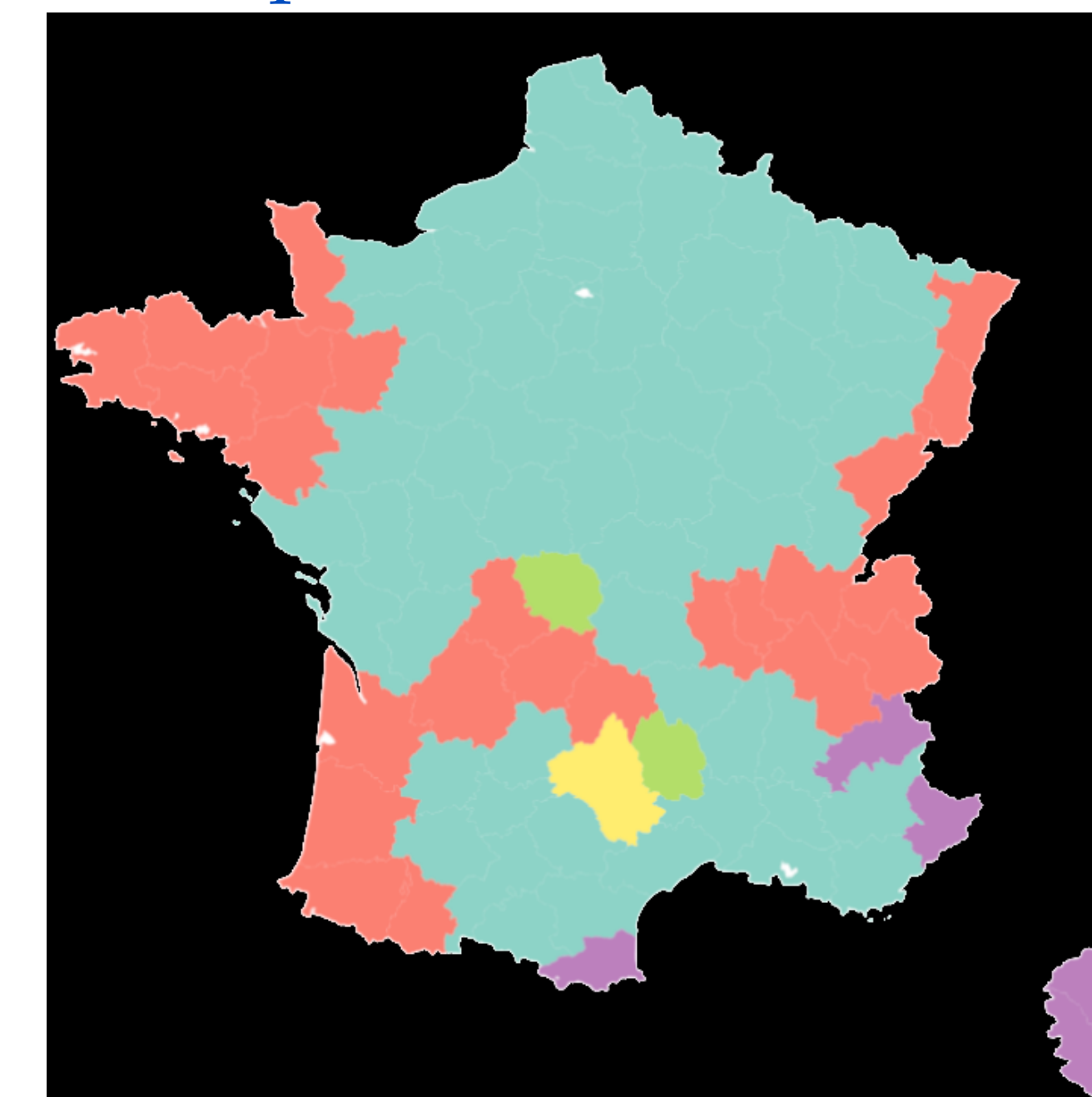
### Large scale computation of the indicator



- Input: Sentinel-2 L2A time series
- Num. of pixels:  $\approx 14$  billions.
- Processing chain: iota2<sup>[6]</sup>
- Runtime: 72h over 40-CPU
- RAM: 512GB

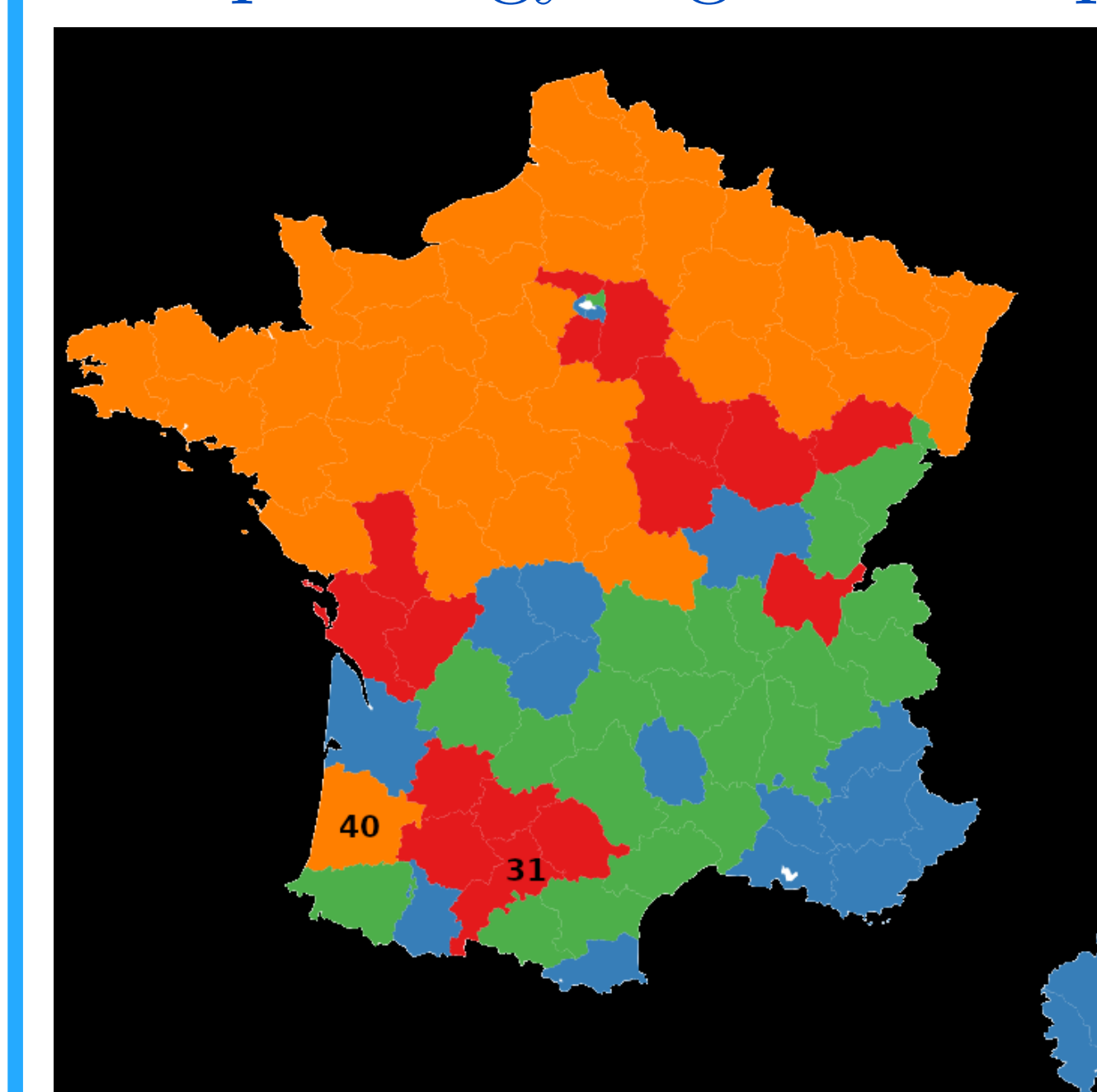
### Majority crop classes per French department

- Wheat
- Maize
- Triticale
- Alfalfa
- Barley



Source:  
French version of the LPIS

### Soil pedology regulations per French department



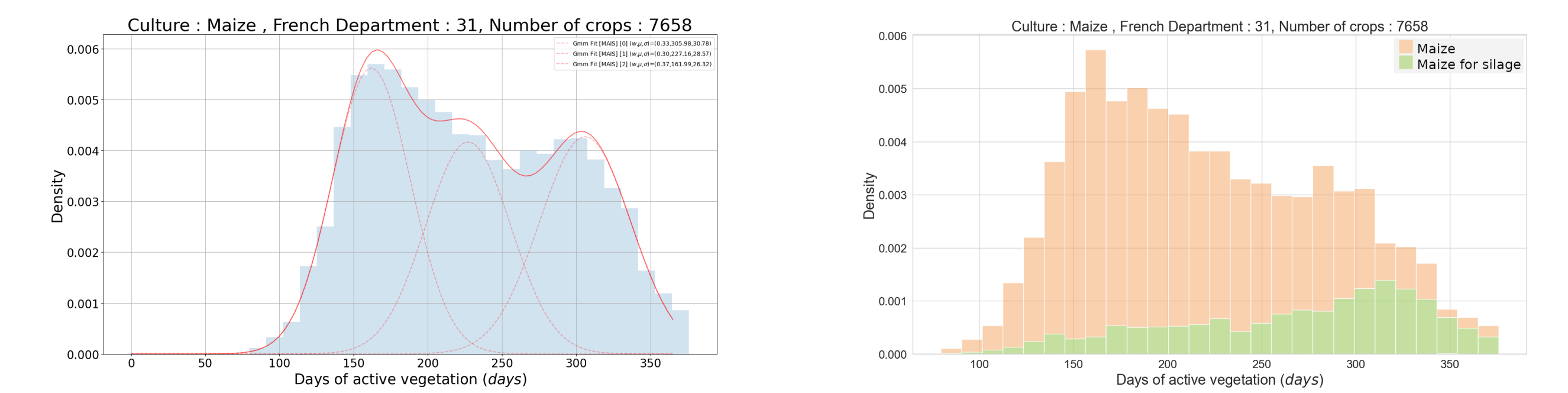
- No restriction
- Nitrate vulnerable zone (NVZ)
- Clay stress zone
- Both Nitrate vulnerable and clay stress

Source for the NVZ:  
Regional official data

Source for the clay stress zones:  
Deduced from SoilGrids<sup>[7]</sup>

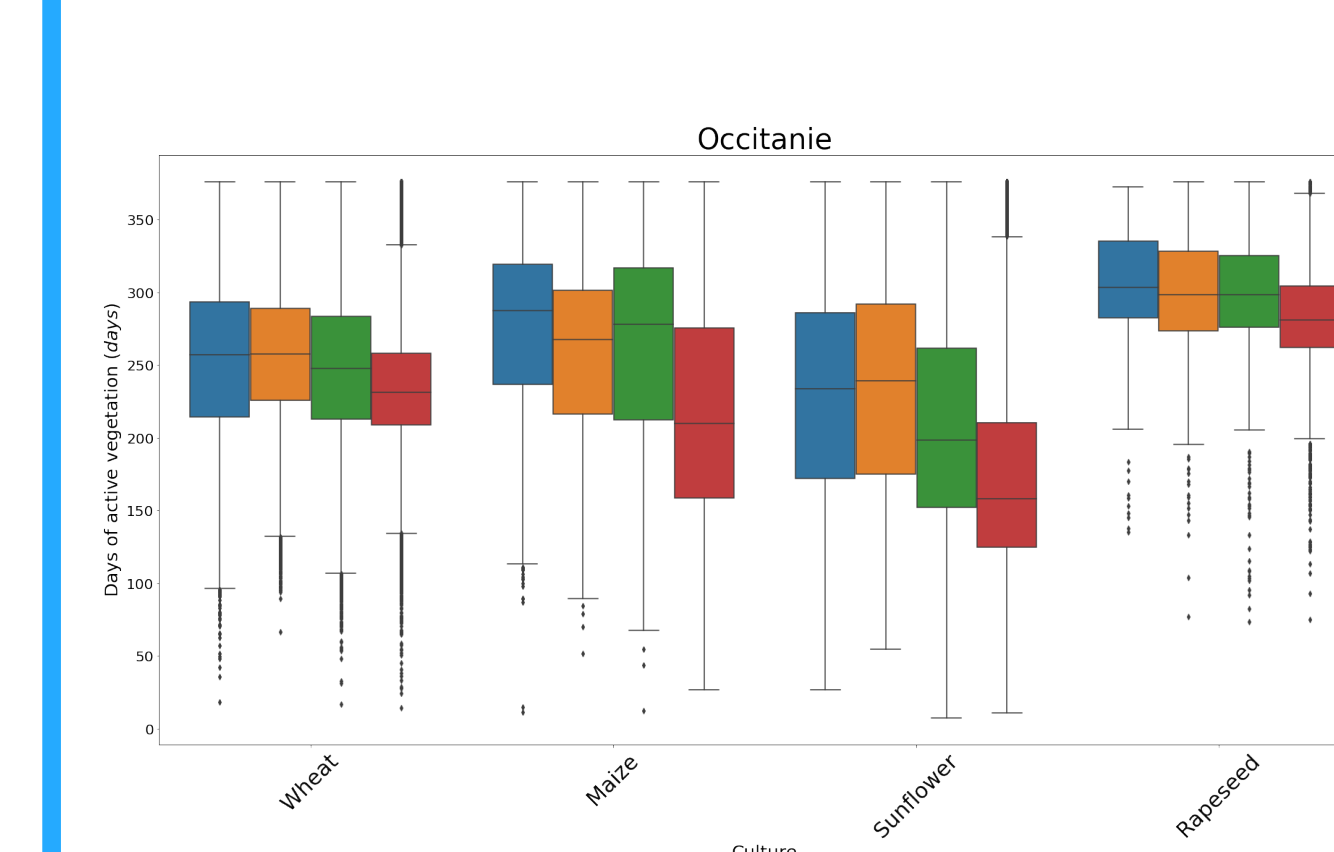
## Analysis

### Regional Statistics of the NDAV



NDAV statistical distribution per region and per crop: on the left, the statistics for the maize is clustered as a mix of 3 gaussians in order to explain the shape with potential specific practices or variety usage. On the right, same statistics but conditioned with the varieties. Signature of catch crops are visible for the 2 varieties.

### Cross Statistics between NDAV and pedology regulations



Those statistics are consistent with the practices observed in this departments. Without restrictions, cover crops are not mandatory. But if grow, they tend to be of long duration. On restricted zone, cover crops are mandatory but tend to be of short duration (less than 3 months)

## Perspectives

- Calculation of the indicator on smaller periods e.g. trimesters.
- Cross statistics with other type of spatialized information
- Analysis of the climatic components (temperature and rain)
- Regional statistical of the uncertainties

## Bibliography

- [1]: <https://www.niva4cap.eu/> (H2020 project)  
 [2]: [https://gitlab.com/niva4cap/uc1b\\_indicators\\_tool](https://gitlab.com/niva4cap/uc1b_indicators_tool)  
 [3]: Ceschia et. al. Agric. Ecosyst. & Environ. 139(3):363-383 (2010)  
 [4]: Smith et.al, AGEE3621 (2010)  
 [5]: <https://www.icos-cp.eu/data-services/about-data-portal>  
 [6]: <https://doi.org/10.5281/zenodo.58150>  
 [7]: <https://soilgrids.org/>