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Assessment of the potential of Earth observation data and deep convolutional neural networks to improve the estimation and forecast of the solar power production in France

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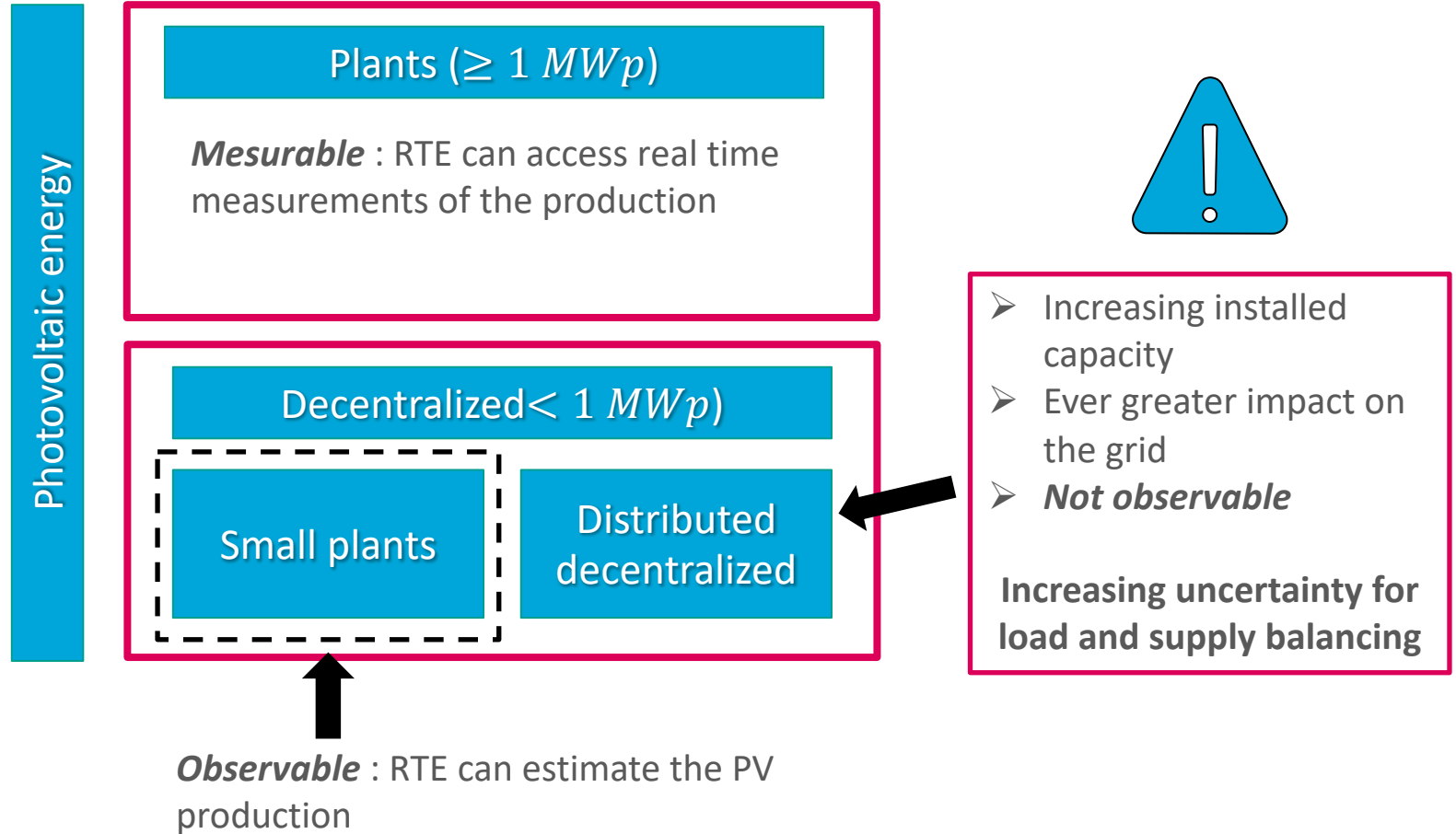
Academic supervisors : Philippe Blanc, Yves-Marie Saint-Drenan

5th July 2022 –MACLEAN @ Cap/RFIAP Workshop

Context and overview

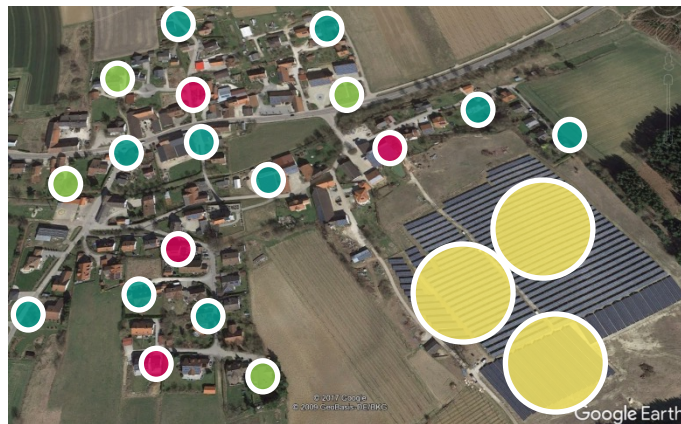
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Not all PV are measured equally

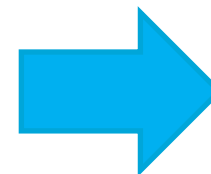
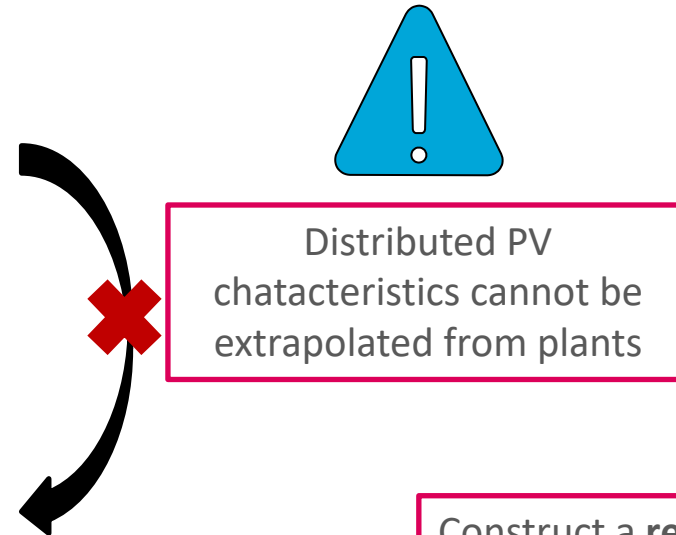


Bridging the gap leveraging a regional PV model and a registry

We can fit a **regional PV Model** to get an accurate estimation of the decentralized PV
However, we need statistics on the characteristics of PV systems



Regional PV model

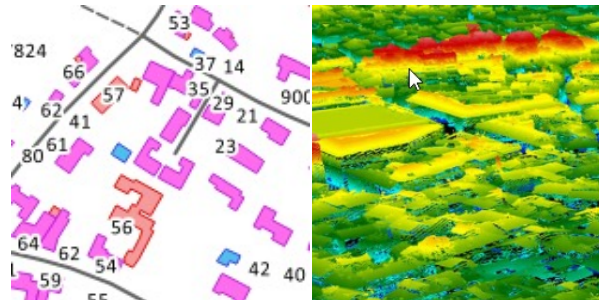


Construct a **registry** containing the following characteristics :

- **Localization**
- **Tilt**
- **Azimuth**
- **Surface area**
- **Installed capacity**

Leveraging deep learning and EO data to build the registry

Previous studies (Yu et al, 2018, Mayer et al, 2022) proved that **deep learning** and **Earth observation data** can be leveraged to **construct large scale PV registries**



Id	Loc.	Tilt	Azim	Inst. Cap.	Area
0	45°, 3°	30°	-10°	3 kWp	12 sqm
1	44°, 3°	45°	-30°	2,9 kWp	10 sqm
2	46°, 3°	10°	0°	30 kWp	100 sqm
...					

1. Detection and segmentation of PV installations

→ Image classification and image segmentation

2. Filtering and characteristics extraction using topological and LiDAR data

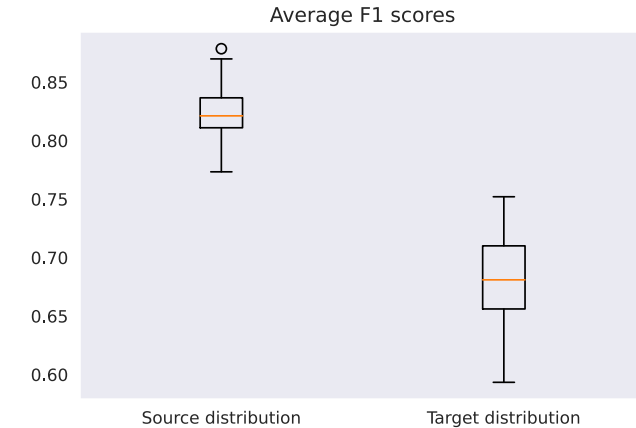
→ Automatic extraction of the characteristics

Outcome : automated PV registry

→ Aggregated and standardized data
→ Expected to be the **largest registry** with this level of detail

Scientific questions

- Performance of current models are worse on France than on their source data. Issue: **sensitivity to domain shift** (which is widespread in machine learning)
- We need to be able to **certify the method**:
 1. We need to understand how domain shift affects a model's accuracy.
 2. We need to assess and investigate the accuracy over the whole deployment area.



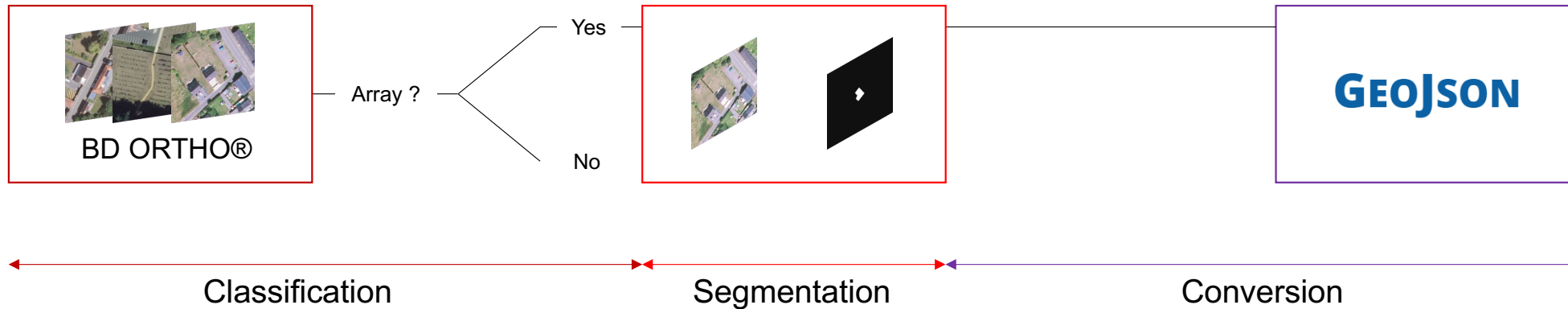
Performance drop from one region to the other (metric : F1 score)



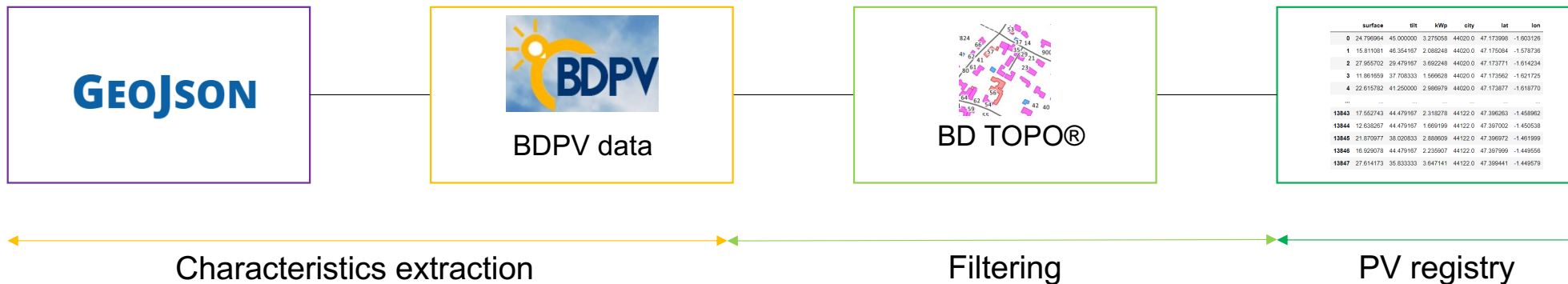
Some false positives

The automated PV registry pipeline

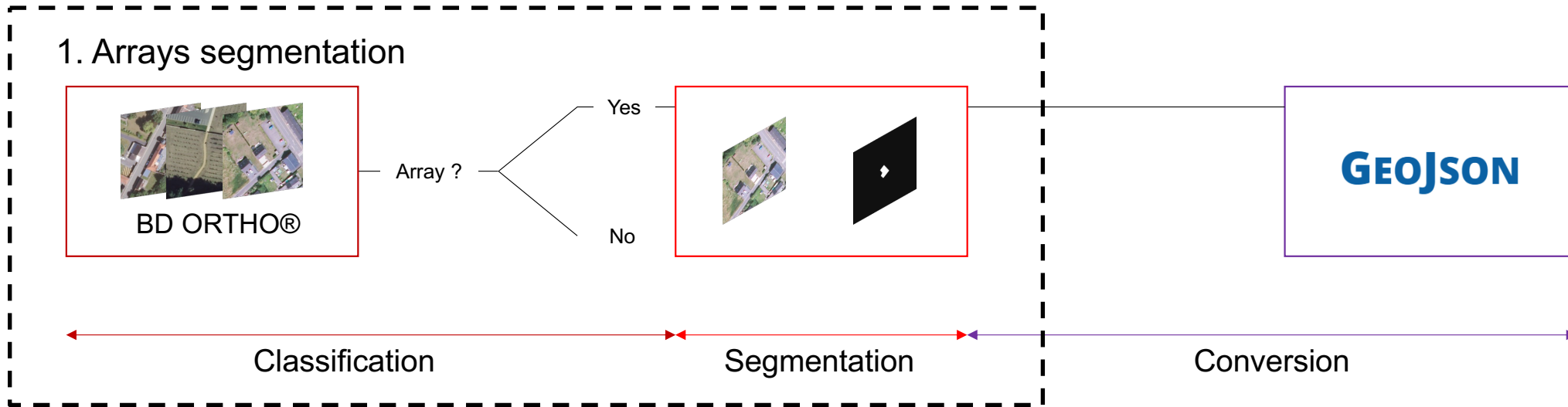
1. Arrays segmentation



2. Characteristics extraction and filtering

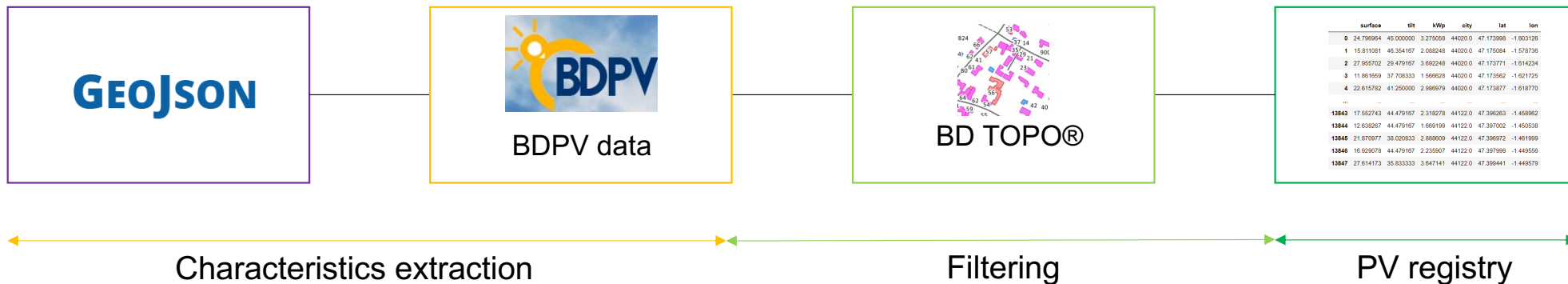


The automated PV registry pipeline



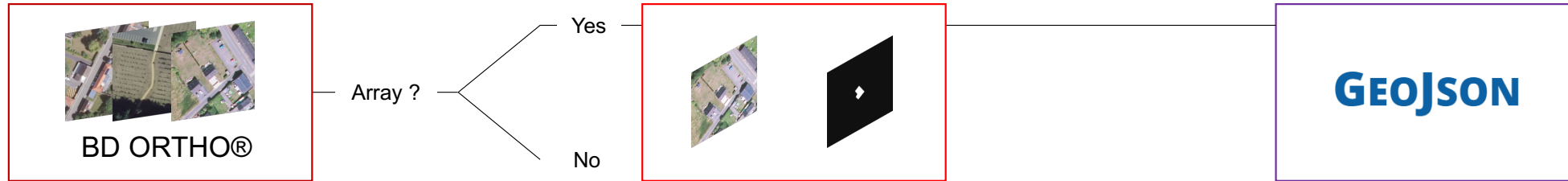
A new training database and an analysis of the sensitivity of CNNs to distribution shifts

2. Characterist



The automated PV registry pipeline

1. Arrays segmentation

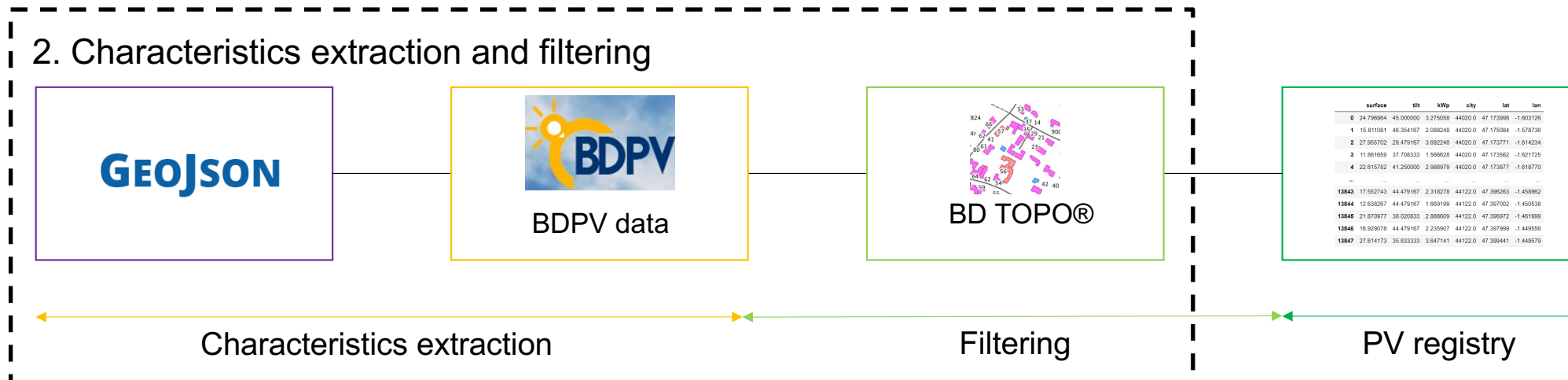


Class

Extraction of the characteristics of the PV installations

Conversion

2. Characteristics extraction and filtering



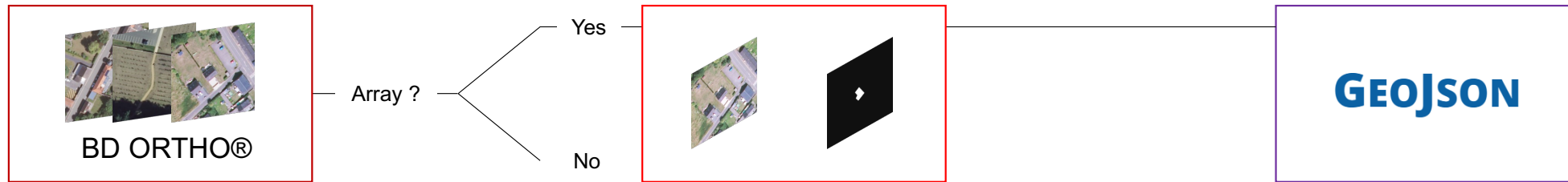
Characteristics extraction

Filtering

PV registry

The automated PV registry pipeline

1. Arrays segmentation

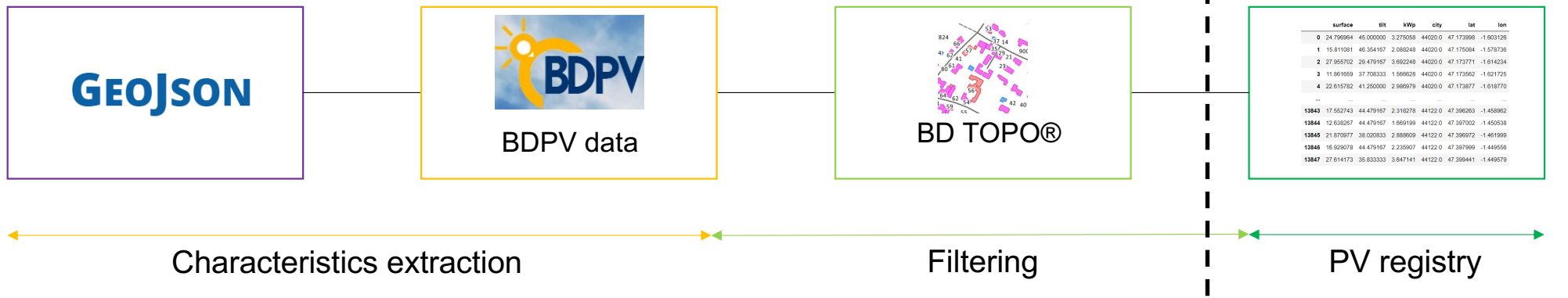


Classification

Segm

Analysis of the accuracy of the data

2. Characteristics extraction and filtering



2 Accuracy assessment

Large scale assessment of the accuracy of the registry

	surface	sit	kWp	city	lat	lon
0	24.706964	45.000000	3.276058	44020.0	47.173998	-1.603126
1	15.811081	46.354167	3.082248	44020.0	47.175084	-1.578736
2	27.955702	29.479167	3.892248	44020.0	47.173771	-1.614234
3	11.861659	37.708333	1.966028	44020.0	47.173962	-1.621725
4	22.615782	41.250000	2.966079	44020.0	47.173877	-1.618770
...
13043	17.552743	44.479167	2.316278	44122.0	47.386283	-1.458952
13044	12.638267	44.479167	1.869199	44122.0	47.397002	-1.450538
13045	21.870977	38.020833	2.888609	44122.0	47.396972	-1.461999
13046	16.929078	44.479167	2.235907	44122.0	47.397999	-1.449556
13047	27.614173	35.833333	3.947141	44122.0	47.399441	-1.449579

PV registry

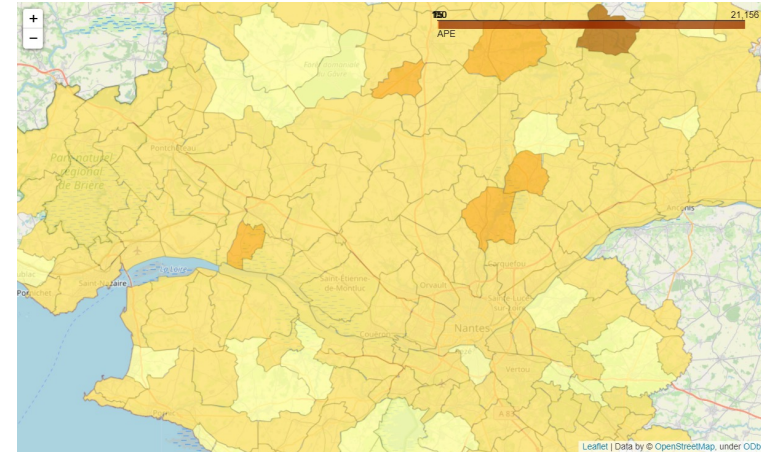
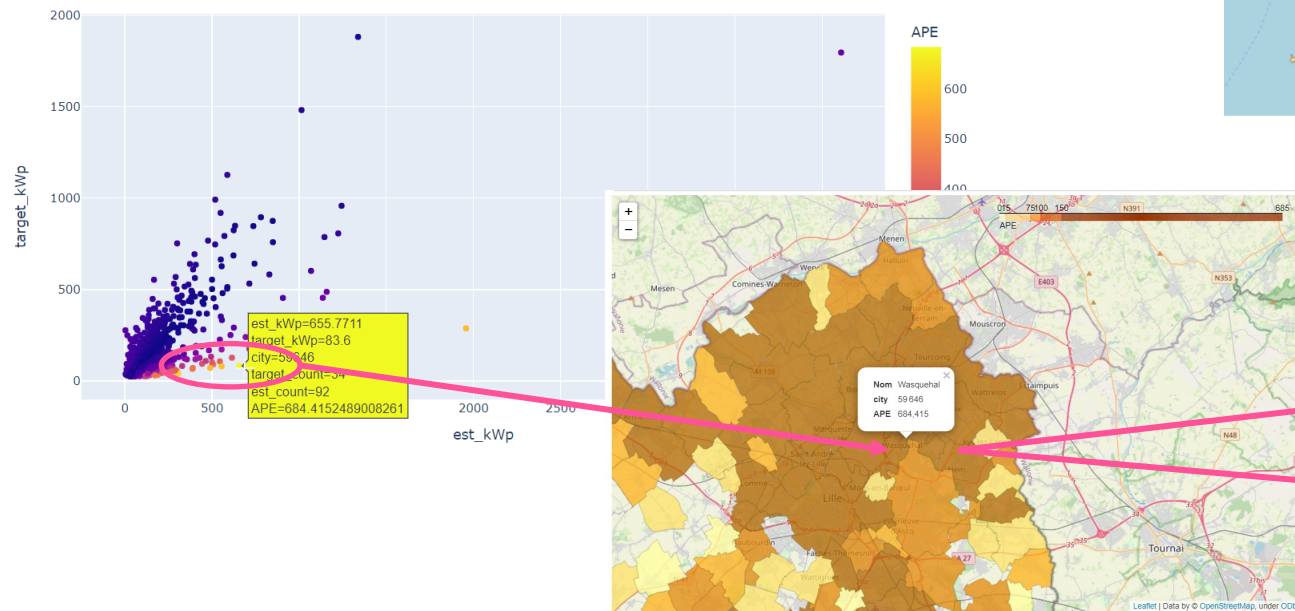
- **Problem:** standard metrics (accuracy, F1, IoU,...) have **no meaning from the application standpoint**
- **Proposed approach :** re-aggregate the characteristics and compare them with the smallest scale available, the national registry of installations (*Registre national d'installations – RNI*)
- The RNI contains the **aggregated installed capacity** and the **number of installations** for installations that have an **installed capacity lower than 36 kWp at the scale of the cities.**

It allows us to **satisfy certifiability constraints:**

1. Control the accuracy over the whole territory
RNI is available everywhere in France
2. Outputs investigation
Tools can be developped to visualize the results

Large scale assessement of the accuracy of the registry

- « End user » accuracy example: average percentage error of the installed capacity, per city
- ➔ Identify « pathological cases »





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Thank you !

Questions ?