INTERMITTANCY REDUCTION :

WIND TIME-SERIES CLASSIFICATION.

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Presented by : Kheirreddine SARI

Summary

1. Context
2. Research question
3. Data & Method
4. Results
5. Conclusion

1. Context

- ➔ France plans to install 33.2 GW wind energy capacities within 2028;
- ➔ Additional investments are needed to reduce impact of renewable energie sources (RES) intermittency;
  - ◆ Increase in energy system costs;
- ➔ Wind variability is reduced according to geographical spread of installed capacities;
  - ◆ presence of different weather regimes;
  - ◆ Balanced wind energy production;
- ➔ Adopting new wind deployment strategies reduces wind intermittency;

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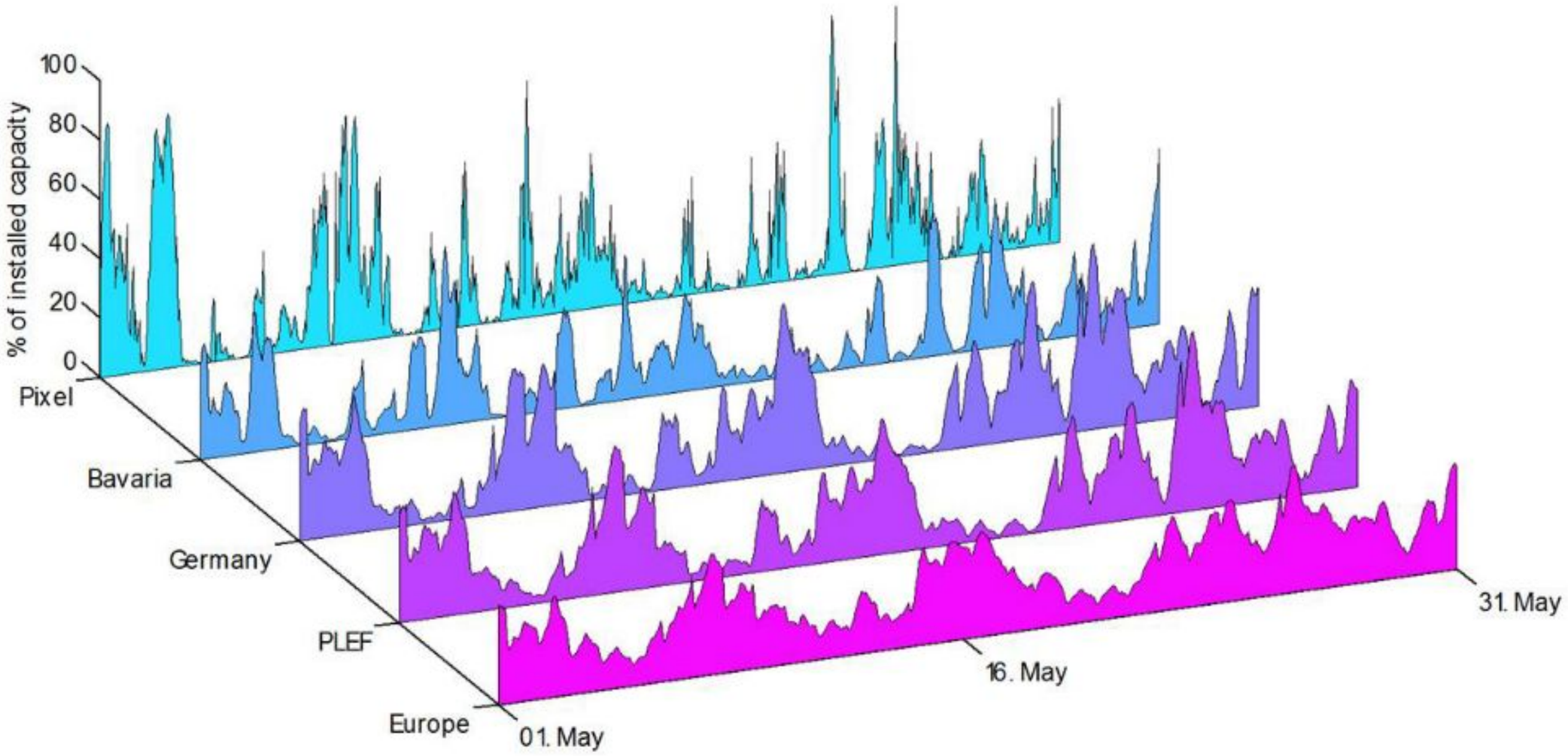

Fig. 1 : Wind electricity production in % of installed capacities (may 2014).
Source: Holtinen & al. (2016).

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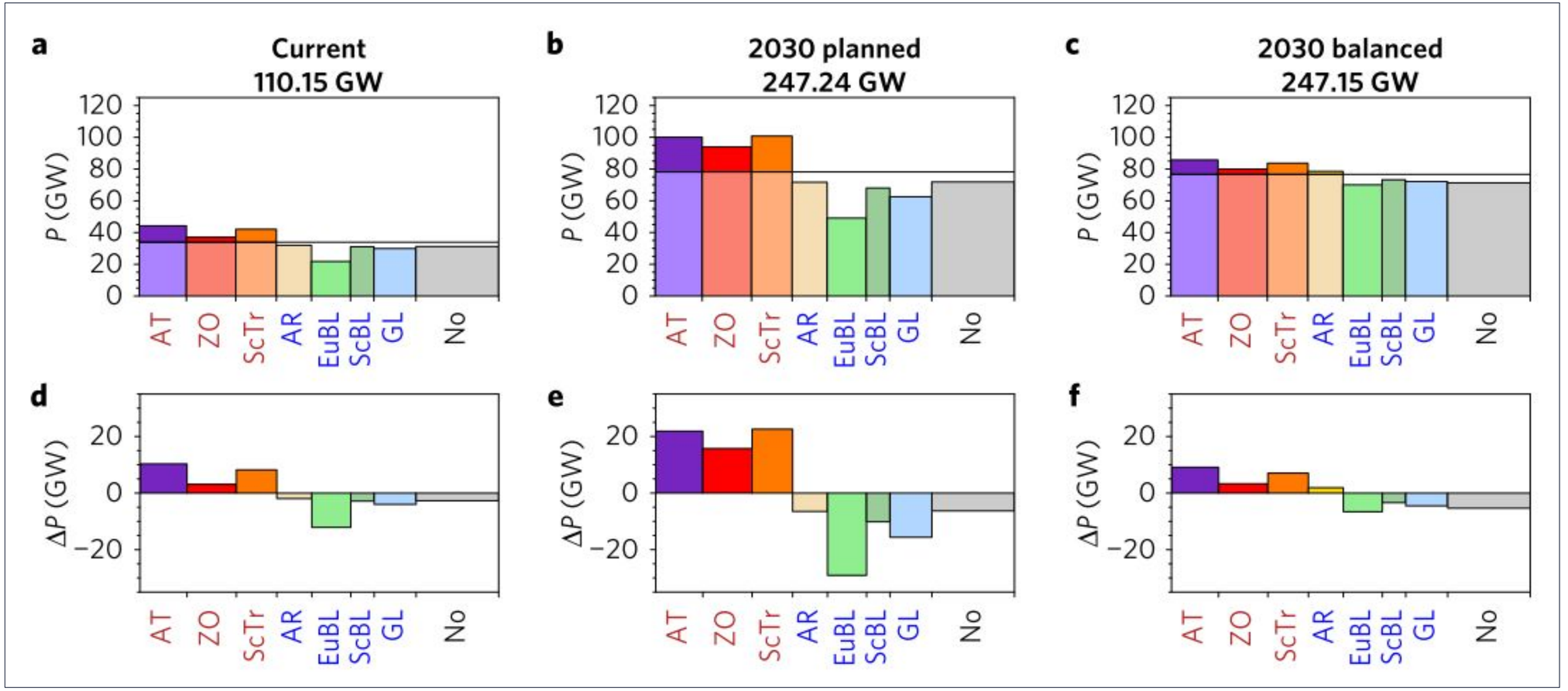

Fig. 2 : Future European wind power output and absolute difference.
Source :Grams & al. (2017).

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2. Research question

Are there complementary wind locations in France?

3.a. Data

- ➔ Dataprovider Météo-France
- ➔ hourly windspeeds data from jan-2016 till dec-2018
- ➔ Mesurement were carried out at 10m height
- ➔ 373 measurement Stations selected
- ➔ Located at North-West and South-East of France

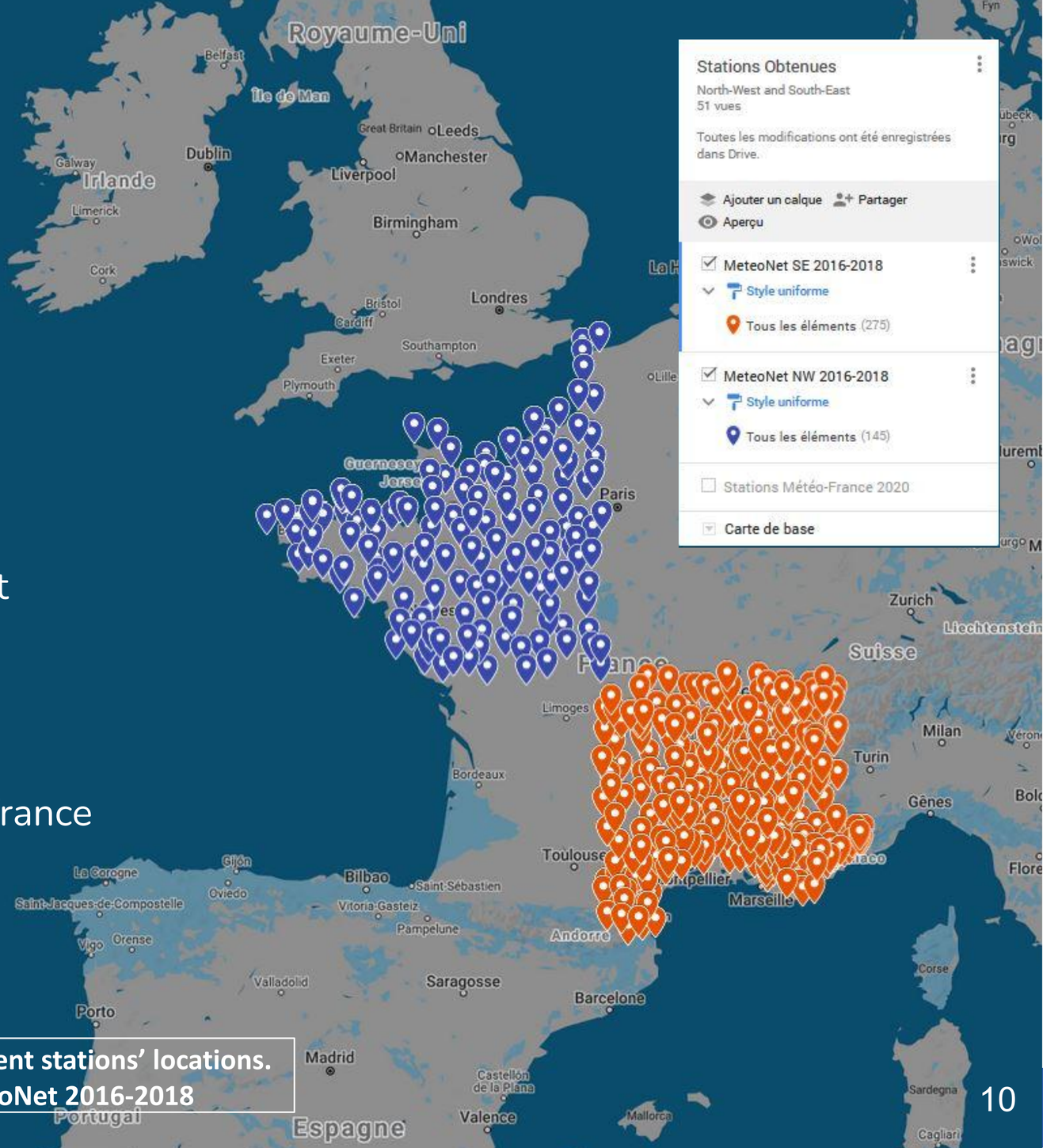

Fig. 3 : Measurement stations' locations. Data : MeteoNet 2016-2018

3.b. Method

Feature-based classifier

- ➔ Time-features are calculated from hourly wind time series (WTS) (e.g., autocorrelation)
- ➔ Principal component Analysis (PCA) is considered for WTS classification;
- ➔ Reduces calculation time.

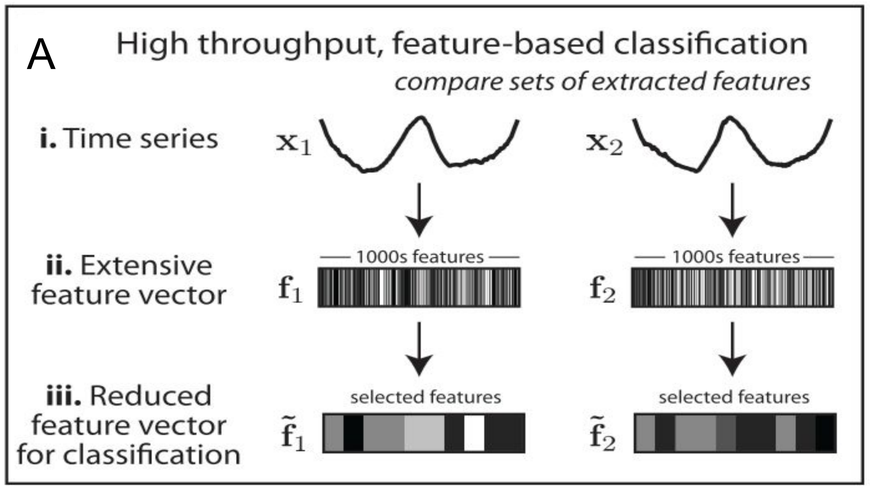

Fig. 4 : Featured-based classification representation. Source : Fultcher & al. (2014).

Instance based classifier

- ➔ Compares two series and measures the (dis)similarity ;
- ➔ Requires high calculation capacities;
- ➔ Reduced sample of weekly average wind speeds is considered.

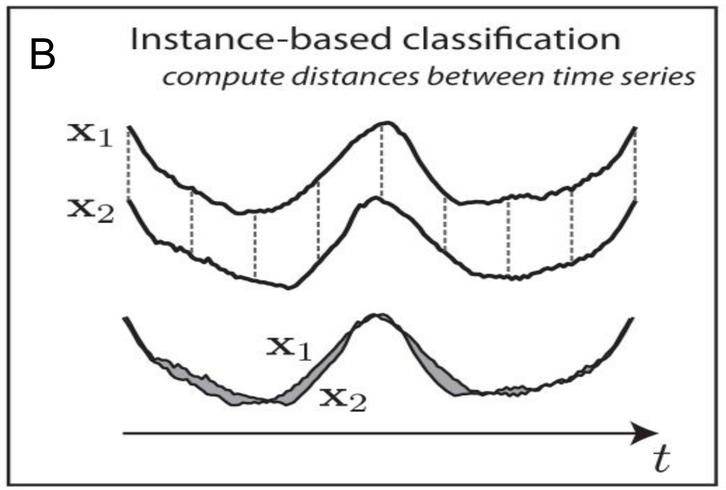

Fig. 5 : Instance-based classification representation. Source : Fultcher & al. (2014).

4.a. Results

Feature based classification

- ➔ The two dimensions express 51.46% of the dataset variation
- ➔ **Dim 1** represents wind sites potential and **Dim 2** represents wind variation
  - ◆ Positive correlation between “eff_summer” and “eff_winter”
- ➔ Labeled variables are well projeted
  - ◆ Spike
  - ◆ Croissing_points
  - ◆ eff_winter

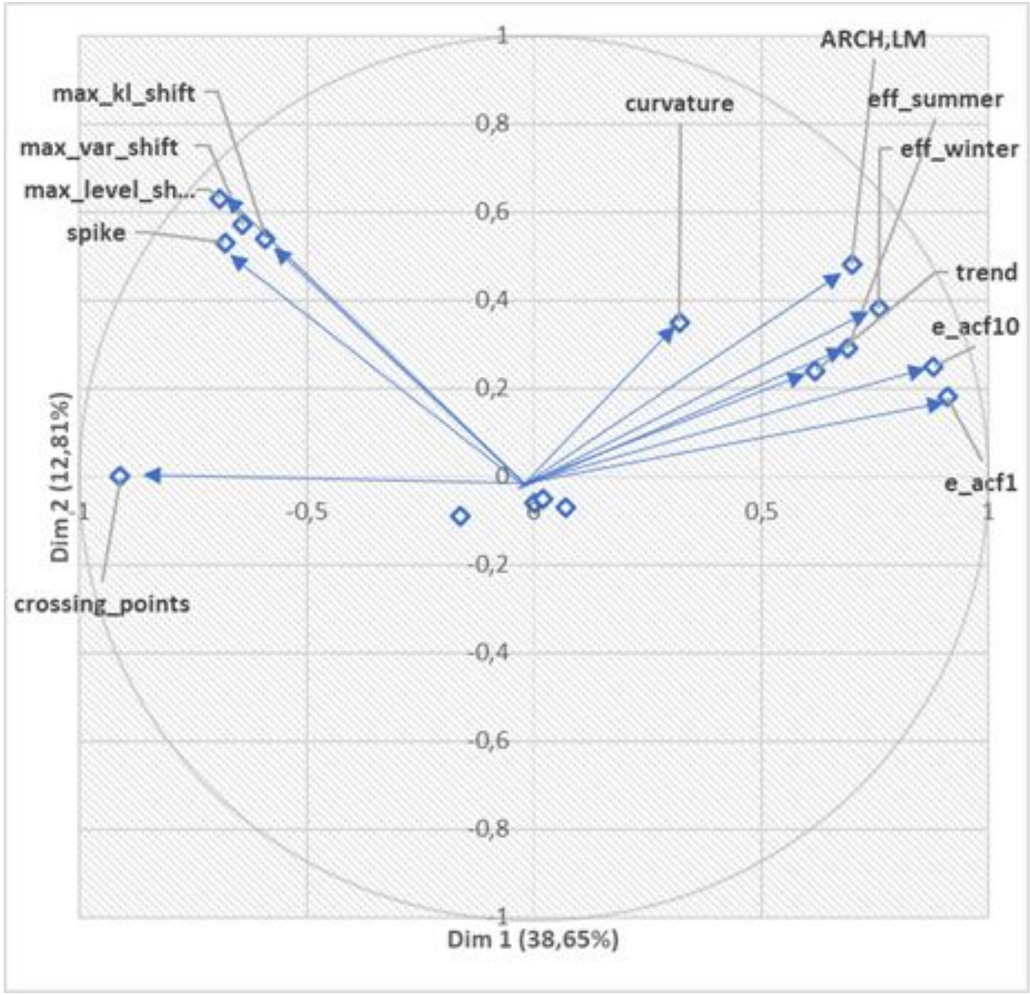

Fig. 6: Variables graph (PCA).
Data: MétéoNet.

4.a. Results

Feature based classification

- ➔ 373 individuals (measurement stations)
- ➔ Labeled individuals are well projeted
- ➔ Group 1 et 2 : represents less productive wind sites
- ➔ Group 3 : represents most productive wind sites

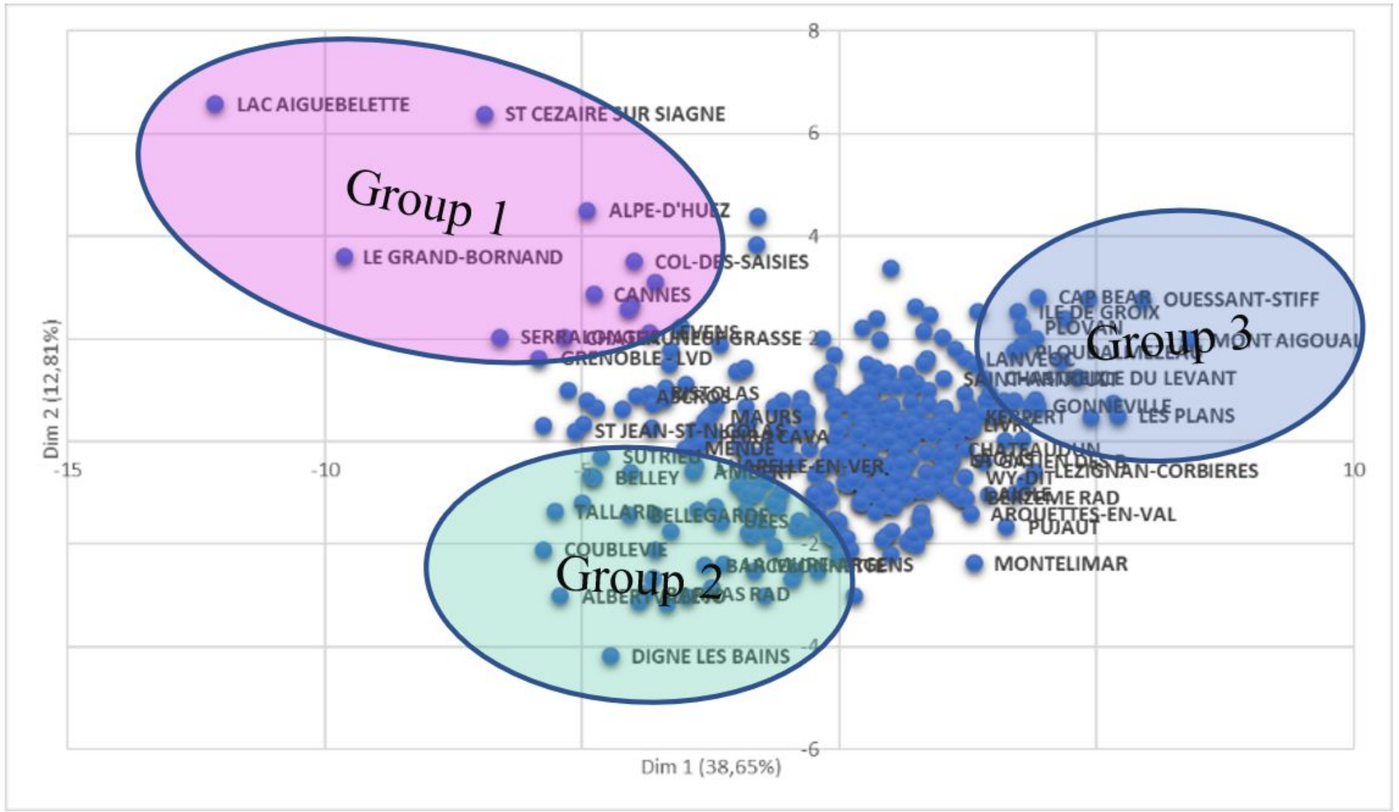

Fig. 7: Individual graph (PCA).
Data: MétéoNet.

4.b. Results

Instance based classification

- ➔ 373 individuals (measurement stations)
  - ◆ Data is z-standardized
- ➔ “Shape Based Distance” (k-shape) obtained highest score
  - ◆ aligns WTS
  - ◆ doesn’t warp in time
- ➔ 12 clusters based on the shape of the WTS
  - ◆ Clusters 9 and 4 are most dissimilar

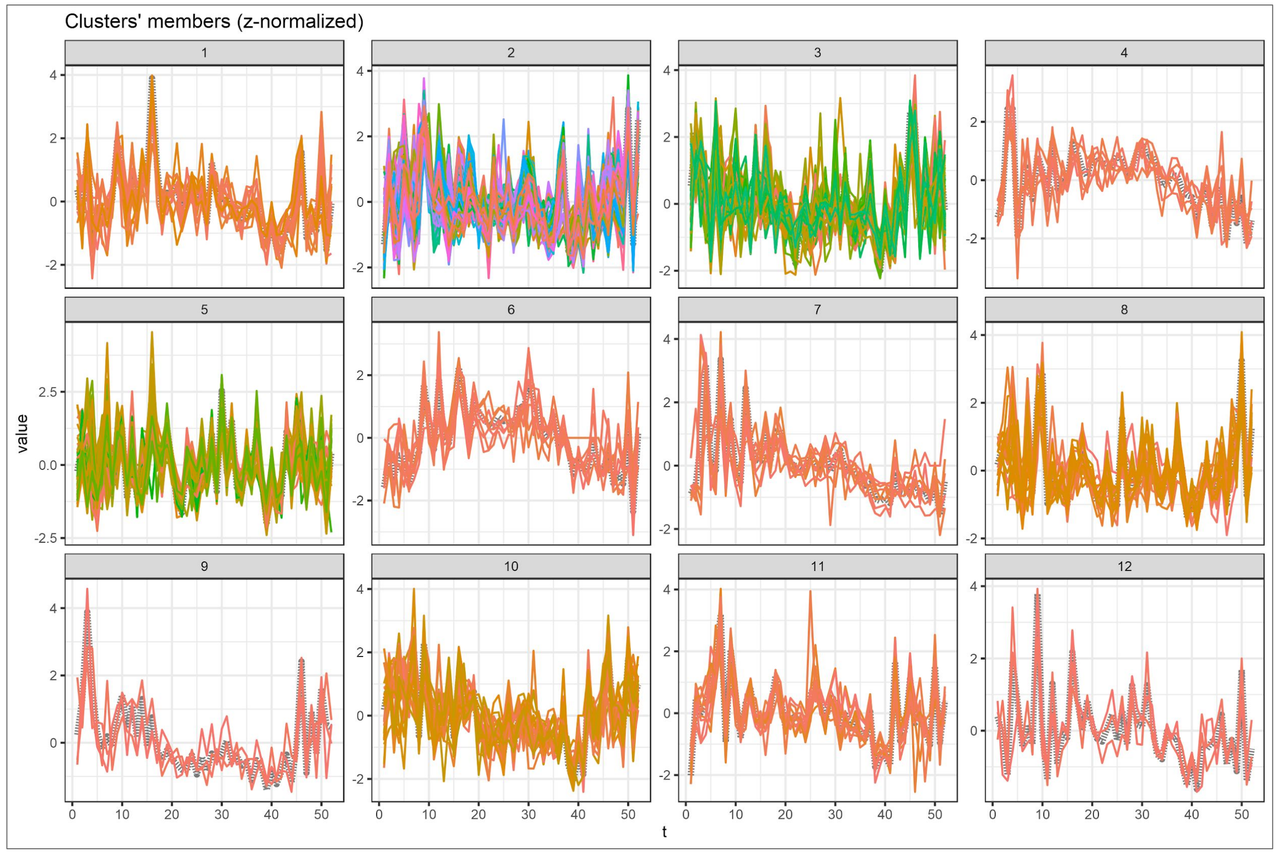

Fig. 8: k-shape clusters’ members. Data: MétéoNet.

4.b. Results

Instance based classification

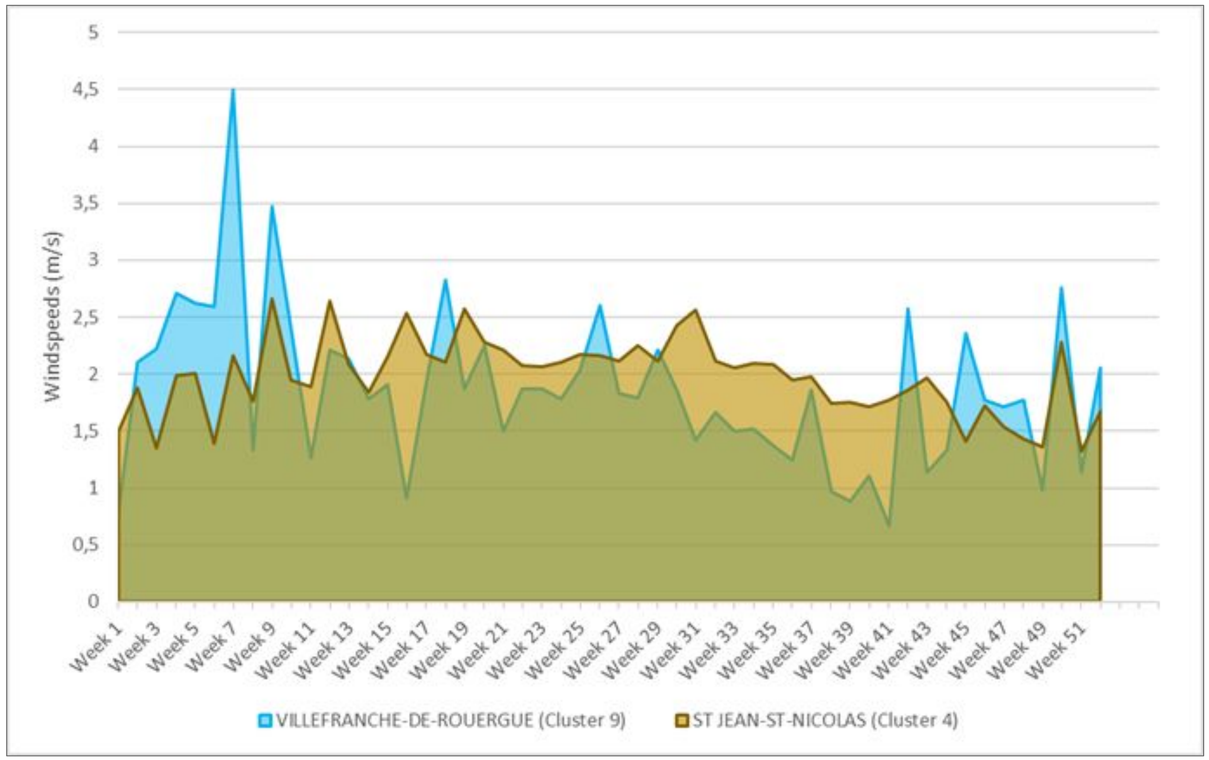

Fig. 9: Weekly windspeed of cluster individuals 4 and 9. Source : MéteoNet.

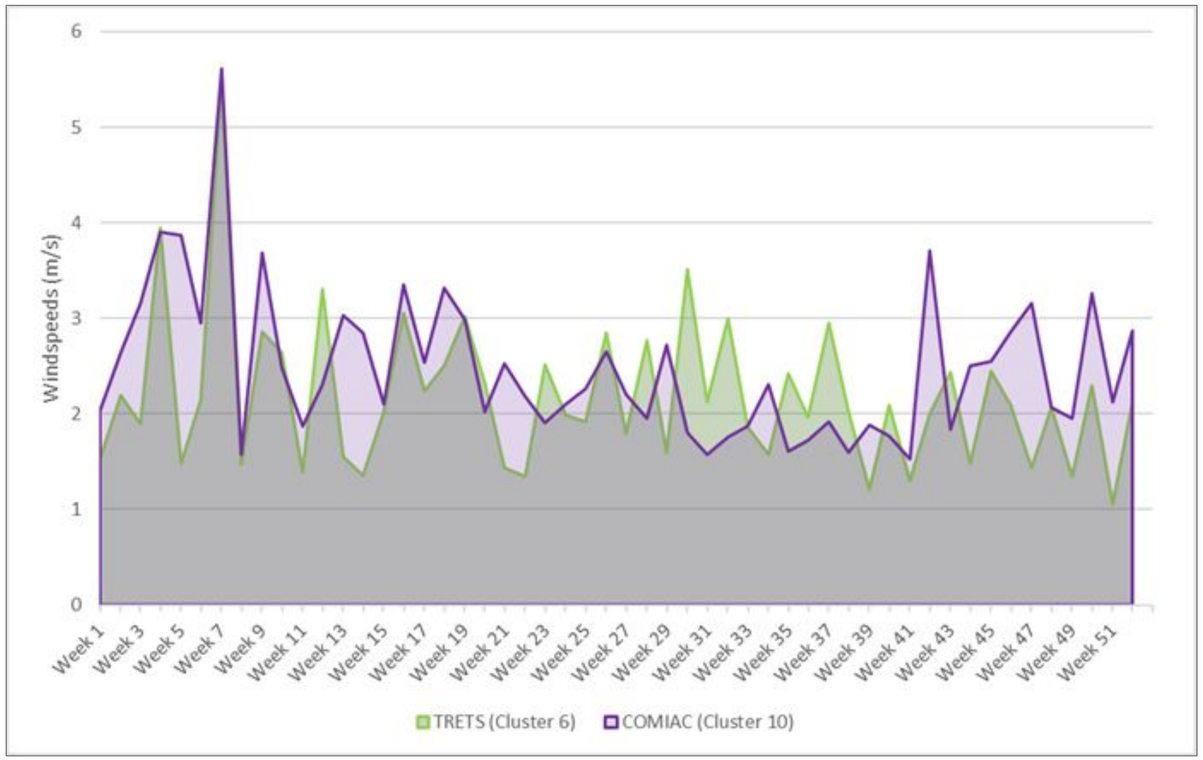

Fig. 10: Weekly windspeed of cluster individuals 6 and 10. Source : MéteoNet.

4. Conclusion

- ➔ Feature based classifiers did not cluster WTS according to their values but according to their characteristics;
  - ◆ Useful to cluster multidiciplinary time series (TS);
  - ◆ Limited for clustering TS with similar structure;

- ➔ Instance based classification allows to pinpoint complementary wind locations
  - ◆ “k-shape” method scored the highest scores compared to “Dynamic Time Warping” (DTW)

- ➔ Weekly frequency provides an idea of the potential for wind energy complementarity

- ➔ In order to reduce wind intermittency, planning solutions implementation is possible in France.

Thank you for listening !

Questions are welcomed

Kheirreddine SARI is currently a second year PhD candidate at Unversity of Montpellier, under the supervision of Professor Benoît Mulkay. His work explores different ways of reducing the intermittency of renewable energies, in particular wind power generation. He also holds an MSc in Energy Economics, Markets and Law and an MSc in Hydrocarbon Economics.

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Annexe

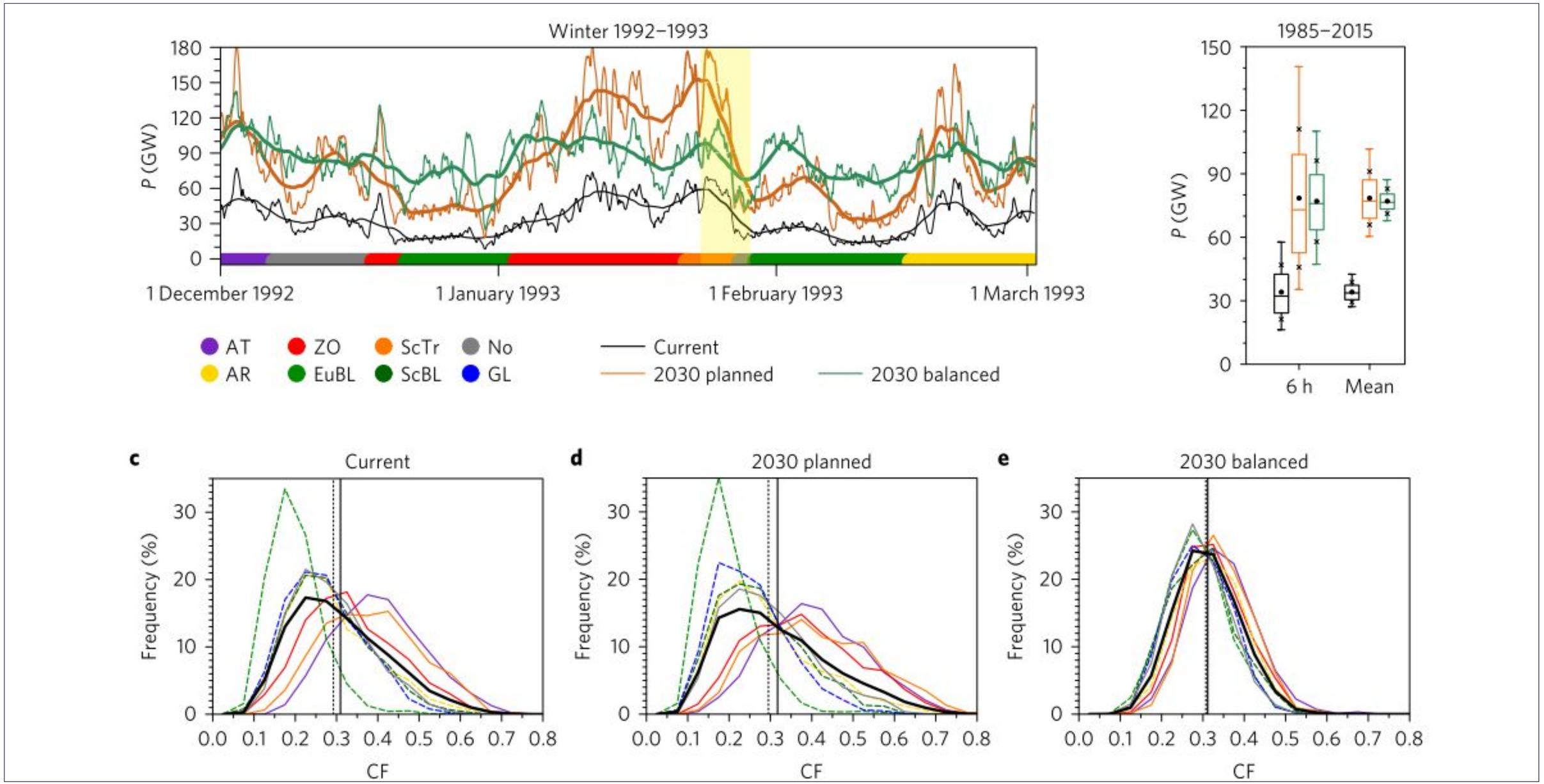

Fig. A.1 : Time series of wind electricity output.
Source :Grams & al. (2017).

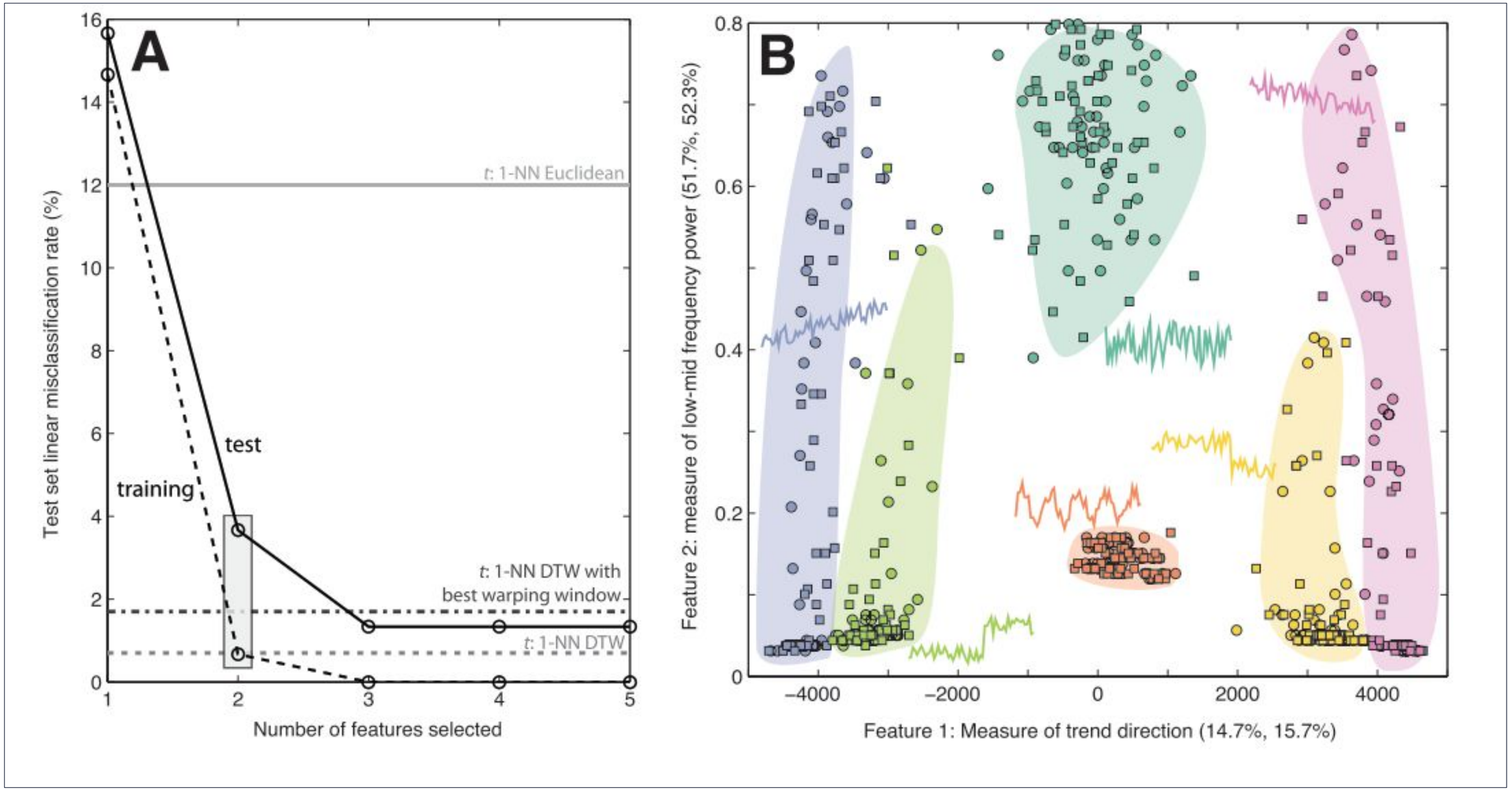

Fig. A.2: Misclassification rate and multidisciplinary timeseries classification.
Source : Fultcher & al. (2014).

	DTW	DTW_LB	kShape	TADPole
Sil (Max)	0,112	-0,226	0,263	-0,101
SF (Max)	1,37E-11	1,38E-11	0,431	3,24E-12
CH (Max)	3,903	4,011	9,595	4,479
DB (Min)	1,161	11,635	0,489	9,776

Tab A.1 : Cluster Validity Indices (CVI) for instance-based clustering.
Data: MétéoNet.

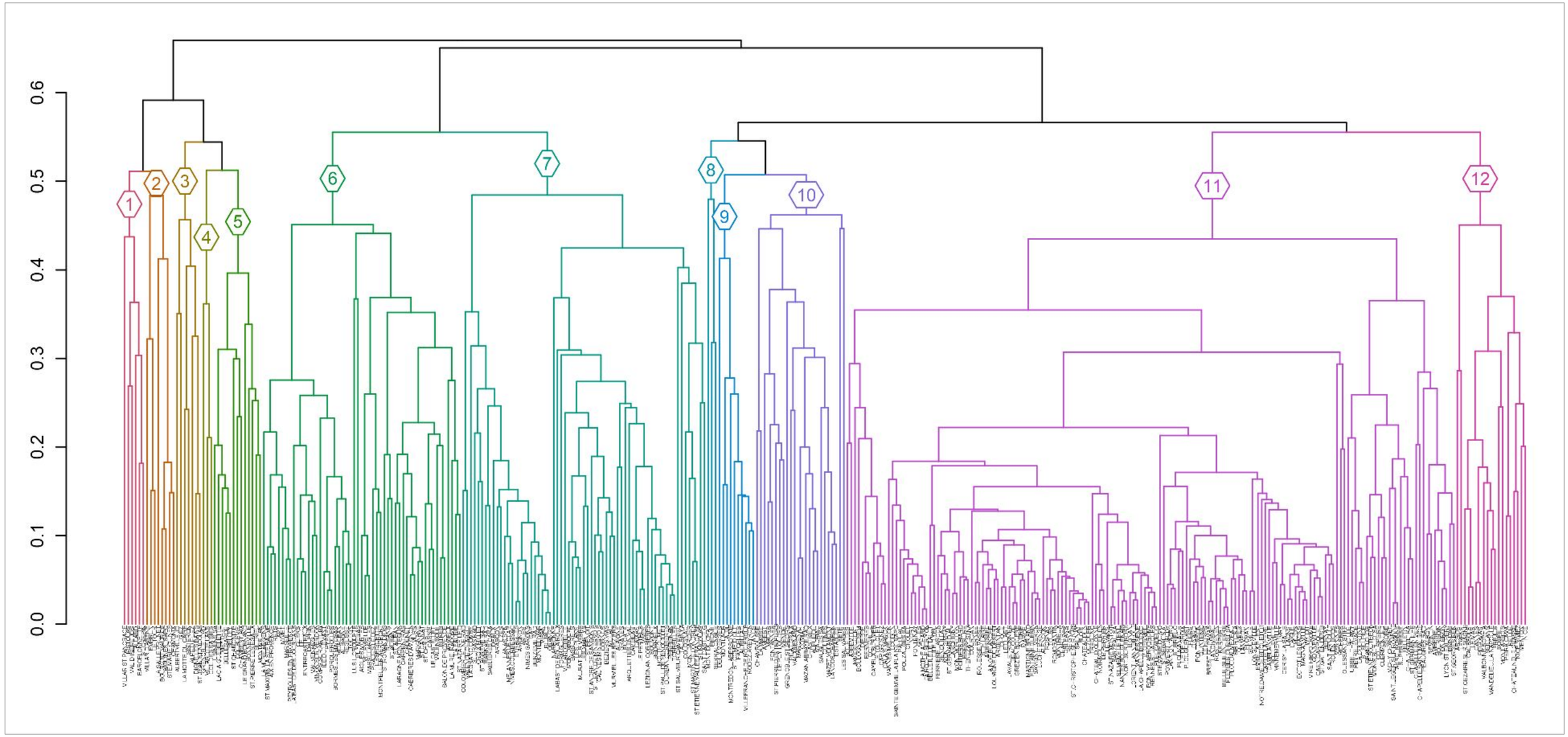

Fig A.3 : Dendrogram of 12 clusters obtained with k-shape.
Data: MétéoNet.

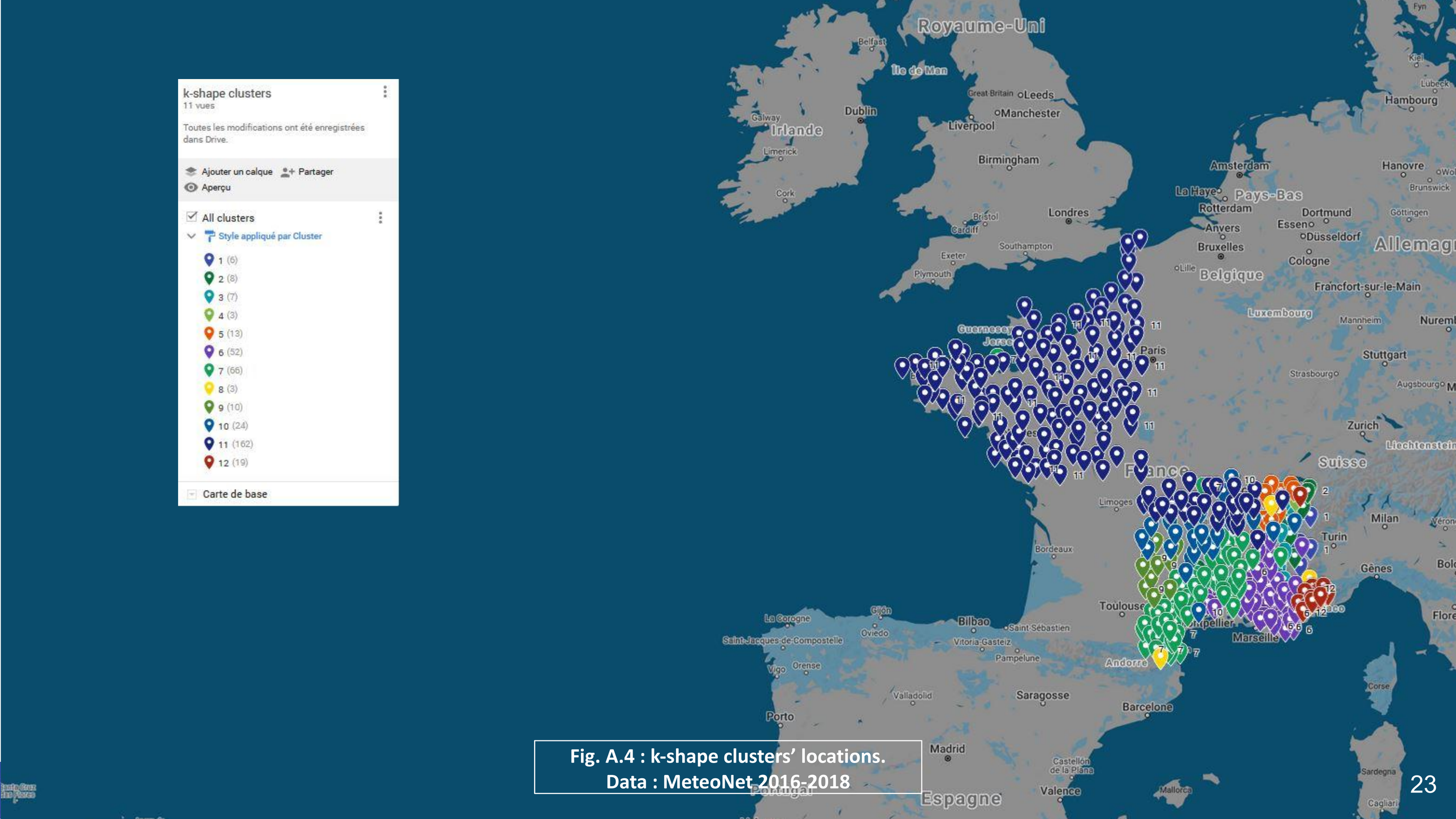

Fig. A.4 : k-shape clusters' locations.
Data : MeteoNet 2016-2018