European Federation of Animal Science

GROUPE

comité du lait

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From MIR predicted fatty acids in bulk tank milk to a health monitoring tool for farmers

S. Franceschini, C. Fastré, C. Nickmilder, D.E. Santschi, D. Warner, M. Bahadi, C. Bertozzi, D. Veselko, F. Dehareng, N. Gengler, and H. Soyeurt

Wallonie recherche CRA-W

Lactanet

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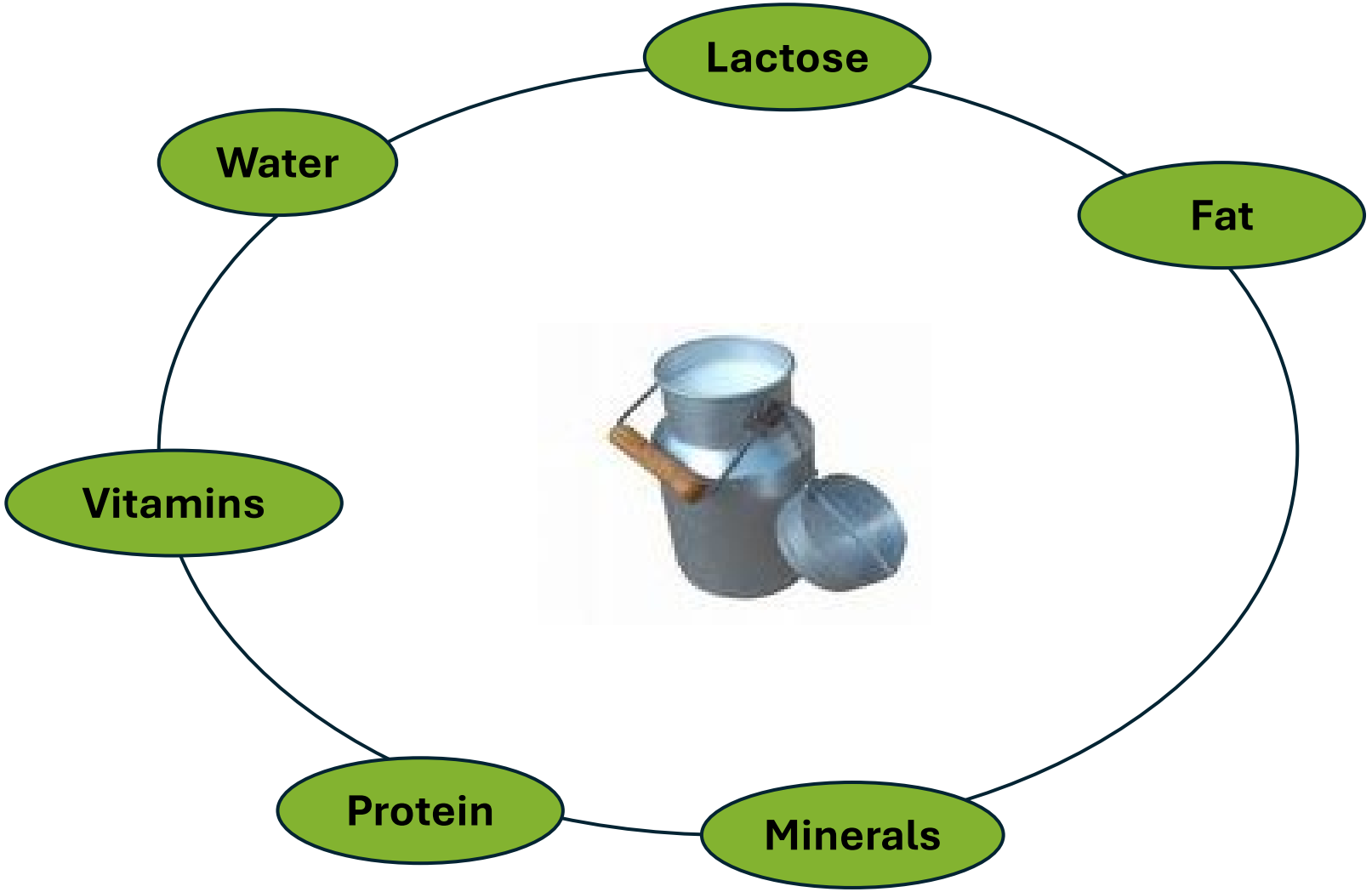
Milk consumption:

Essential in enhancing nutrition and health

- During pregnancy :
  - increases birth weight in offspring
- During childhood :
  - increasing height and reducing overweight and obesity
- During adulthood :
  - positive effects in terms of reducing risk of all-cause mortality

(FAO, 2023)



Milk composition is essential for milk quality !

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Lactose

Water

Fat

Vitamins

More than 400 Fatty Acids !

Protein

Minerals

Milk composition is essential for milk quality !

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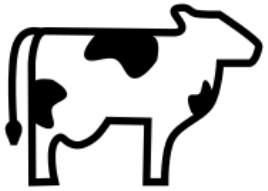
Milk Recording

Milk Payment

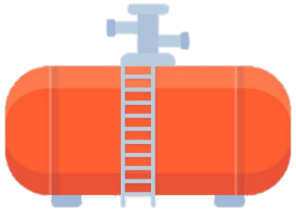
Milk Recording

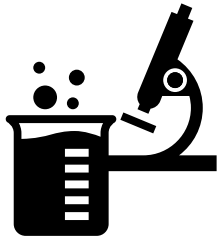


Every 4-6 weeks

Mostly for genetics

Milk Payment





Every 1-3 days

Mostly for Milk Payment

From mid infrared spectra to predictions?

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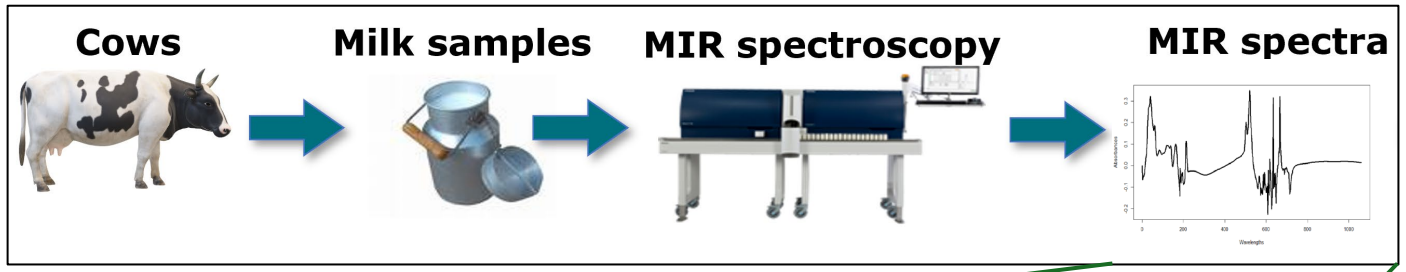
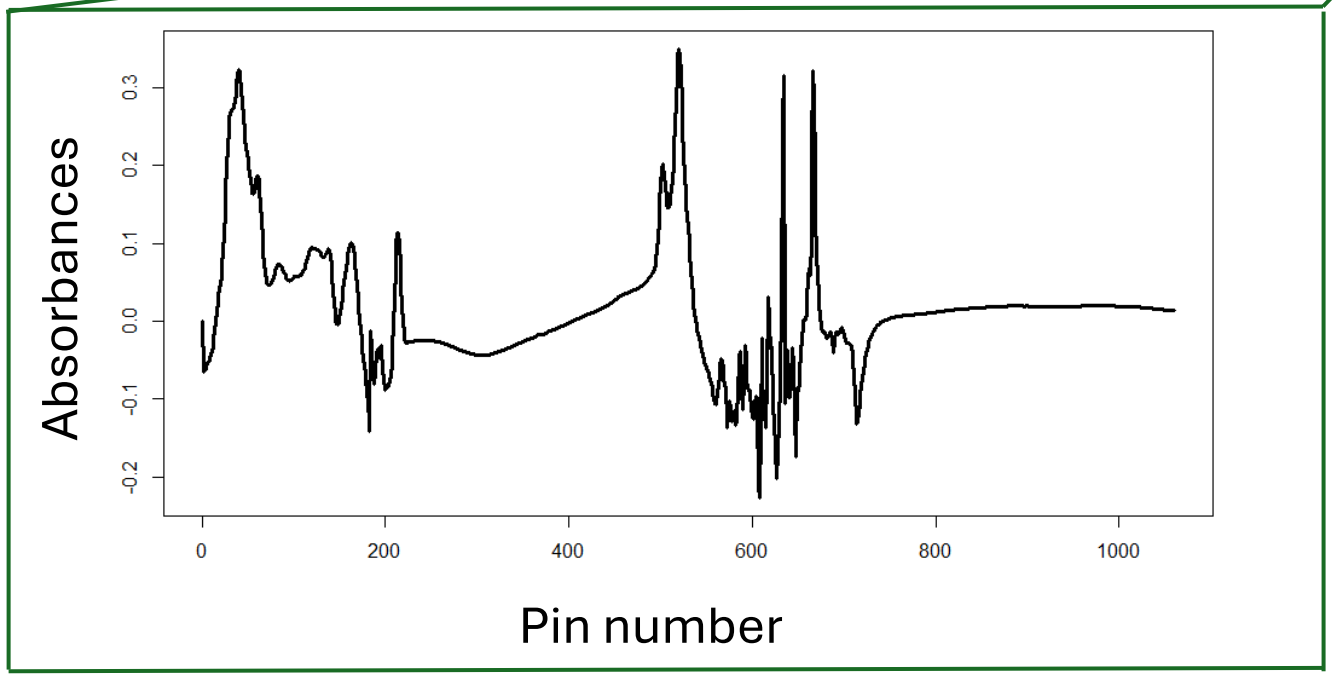


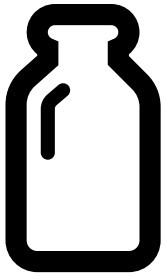


Collect Data

Create a model

Predict new values

Fatty Acids Profile



De novo FA	**C4:0**
	C6:0
	C8:0
	C10:0
	C12:0
	C14:0
	C15:0
Mixed FA	C16:0
	C16:1 cis-9
Preformed FA	C17:0
	C18:0
	C18:1 cis-9
	C18:2 cis-9, cis-12
	C18:3 cis-9, cis-12, cis-15

(Jensen, 2002)

Fatty Acids Profile

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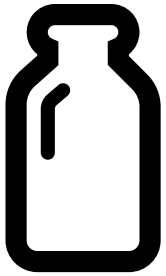
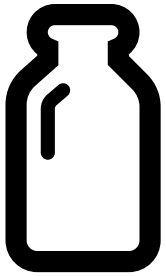


De novo FA	C4:0
	C6:0
	C8:0
	C10:0
	C12:0
	C14:0
	C15:0
Mixed FA	**C16:0**
	C16:1 cis-9
Preformed FA	C17:0
	C18:0
	C18:1 cis-9
	C18:2 cis-9, cis-12
	C18:3 cis-9, cis-12, cis-15

(Jensen, 2002)

Fatty Acids Profile



De novo FA	C4:0
	C6:0
	C8:0
	C10:0
	C12:0
	C14:0
	C15:0
Mixed FA	C16:0
	C16:1 cis-9
Preformed FA	**C17:0**
	C18:0
	C18:1 cis-9
	C18:2 cis-9, cis-12
	C18:3 cis-9, cis-12, cis-15

(Jensen, 2002)

Fatty Acids Profile

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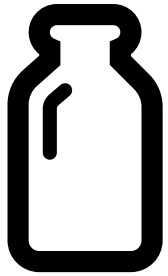
How to handle those predictions ?



De novo FA

C4:0

C6:0

C8:0

C10:0

C12:0

C14:0

C15:0

Mixed FA

C16:0

C16:1 cis-9

Preformed FA

C17:0

C18:0

C18:1 cis-9

C18:2 cis-9, cis-12

C18:3 cis-9, cis-12, cis-15

(Jensen, 2002)

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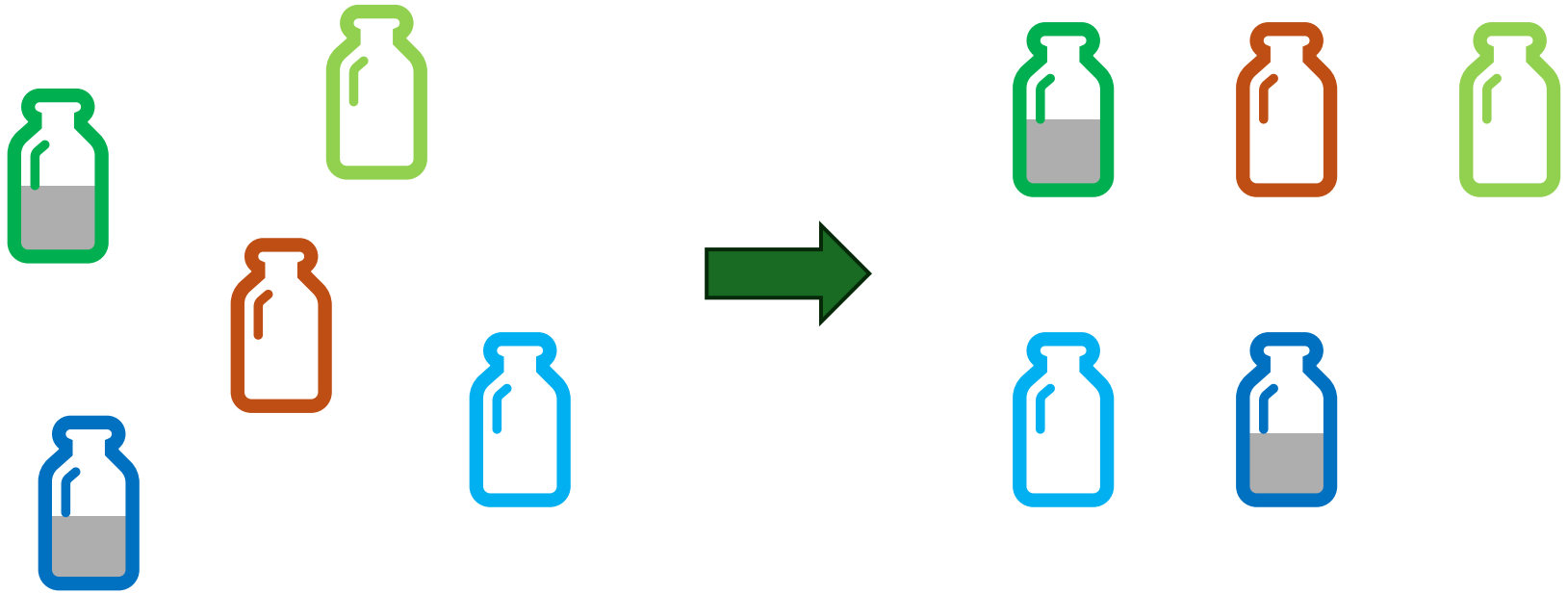
Unsupervised Learning



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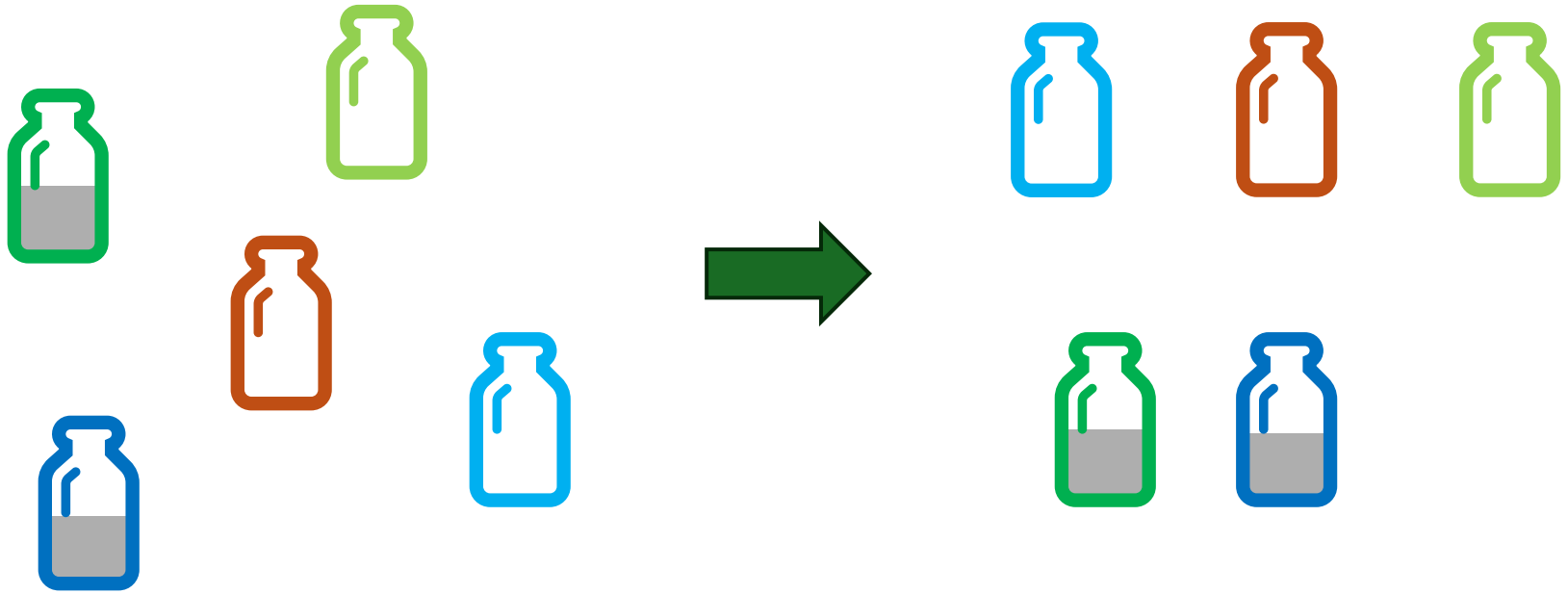
Unsupervised Learning



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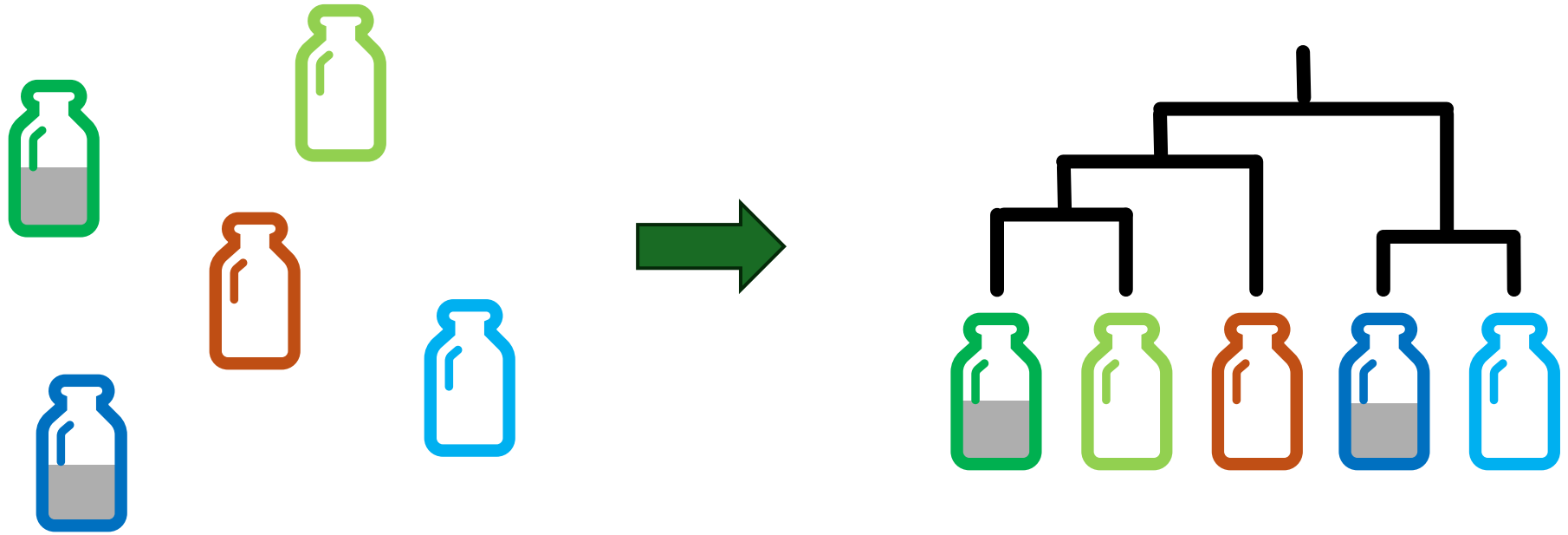
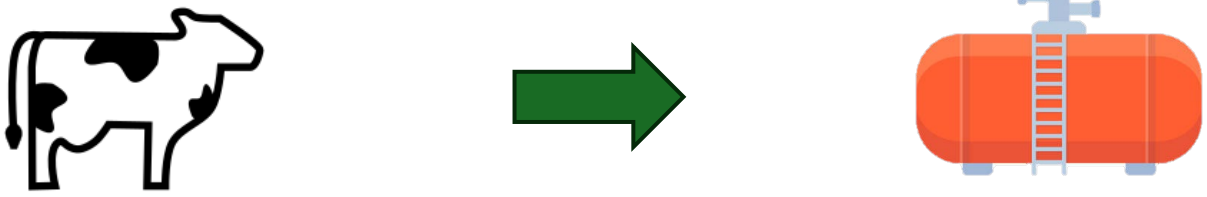
Hierarchical Clustering



J. Dairy Sci. 105:6760–6772
https://doi.org/10.3168/jds.2022-21975

Can unsupervised learning methods applied to milk recording big data provide new insights into dairy cow health?

S. Franceschini,[1]* C. Grelet,[2] J. Leblois,[3] N. Gengler,[1] GplusE consortium,† and H. Soyeurt[1]
[1]University of Liège, Gembloux Agro-Bio Tech (ULiège-GxABT), 5030 Gembloux, Belgium
[2]Walloon Agricultural Research Center (CRA-W), 5030 Gembloux, Belgium
[3]Walloon Breeders Association Group (Elevéo by Awé groupe), 5590 Ciney, Belgium



Dataset of predictions

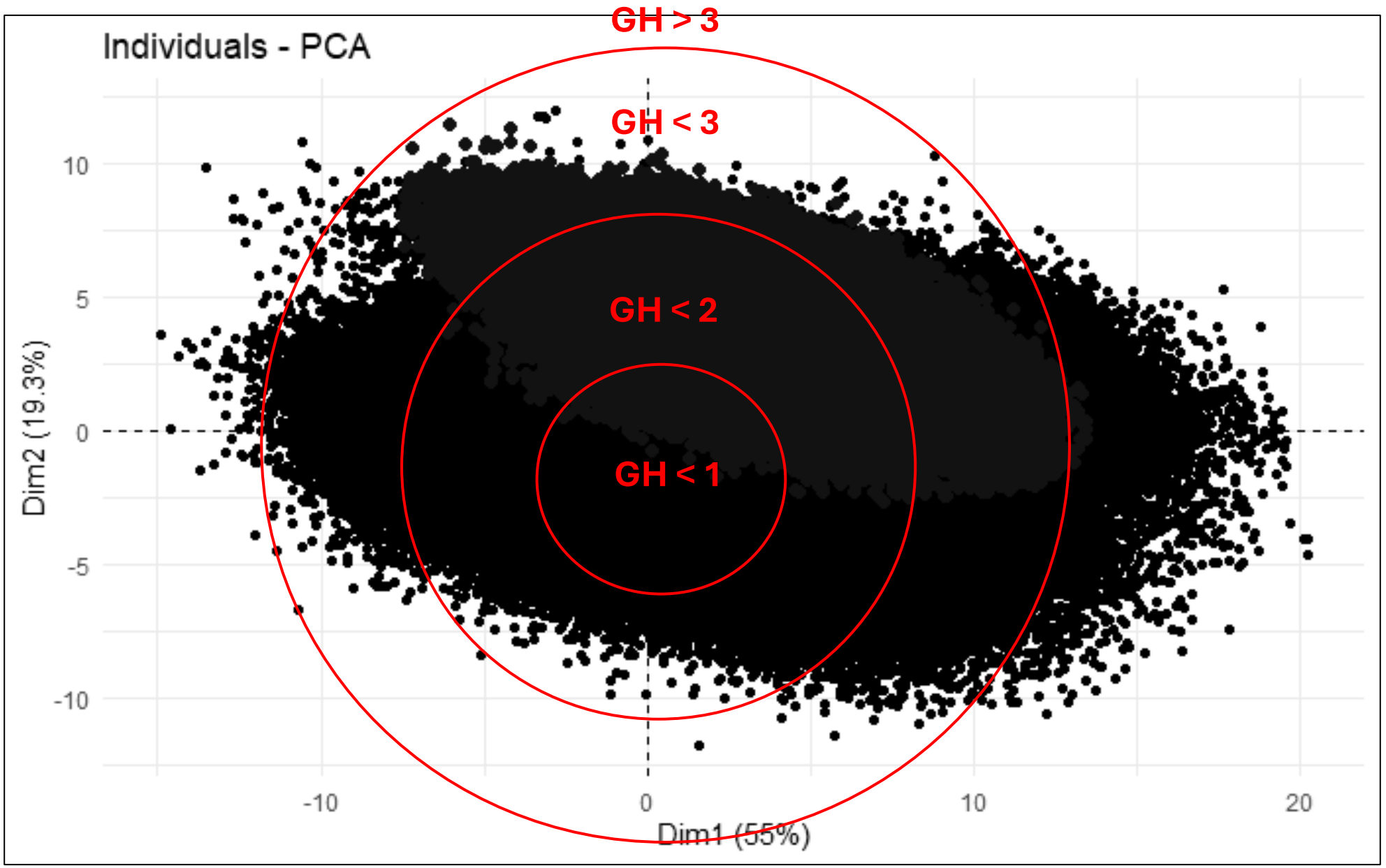
De novo	Mixed	Preformed	Other
C4	C16	C17	Saturated FA
C6	C16:1	C18	Monounsaturated FA
C8		Total C18:1trans	Polyunsaturated FA
C10		C18:1cis9	Unsaturated FA
C12		Total C18:1cis	Short chain FA
C14		Total C18:2	Medium chain FA
C14:1cis9		C18:2cis9cis12	Long chain FA
		C18:2cis9trans11	Branched FA
		C18:3cis9cis12cis15	Omega3
			Omega6
			Odd chain FA
			Total Trans FA
			Total C18:1

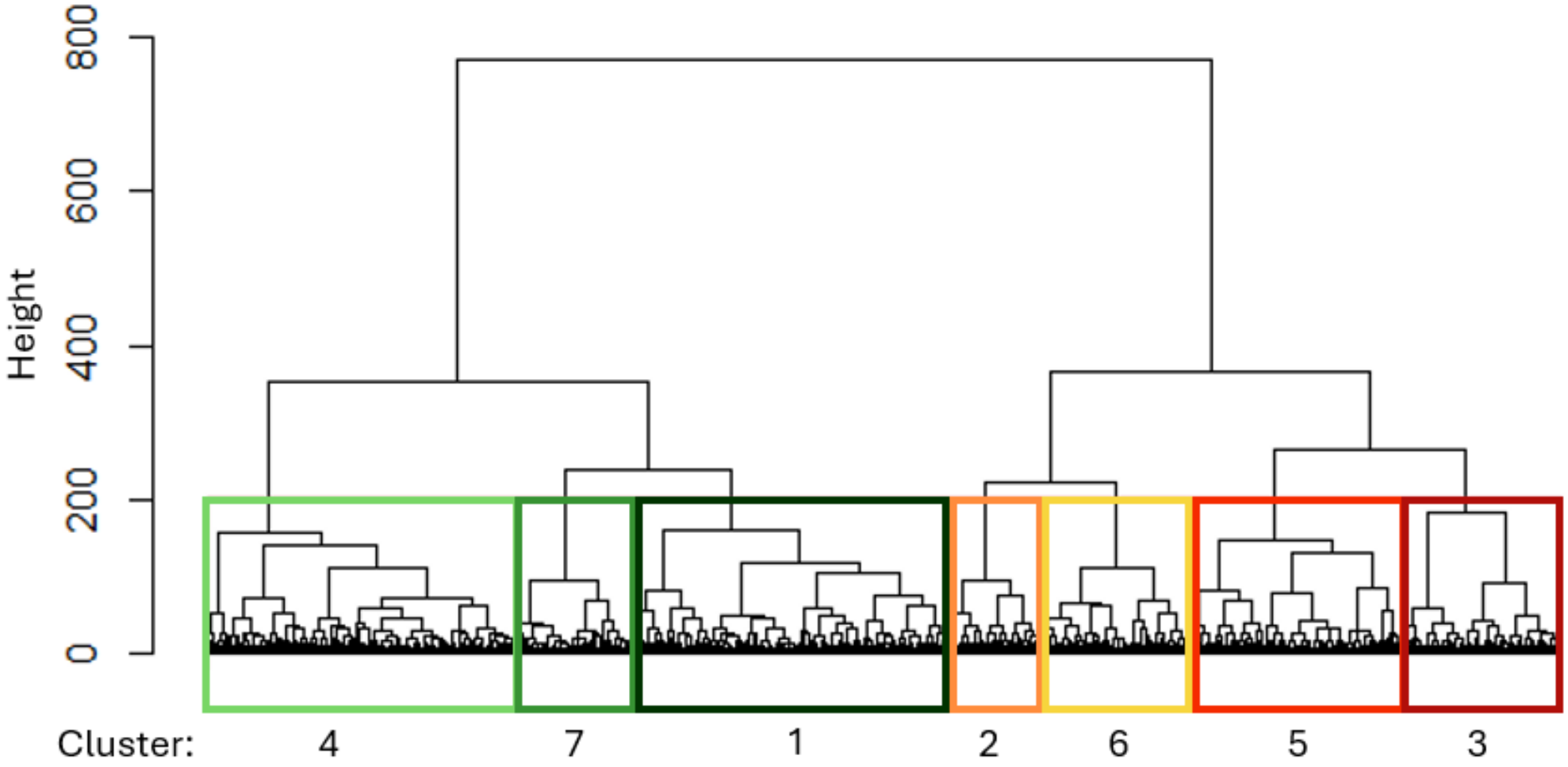
Walloon Dataset :

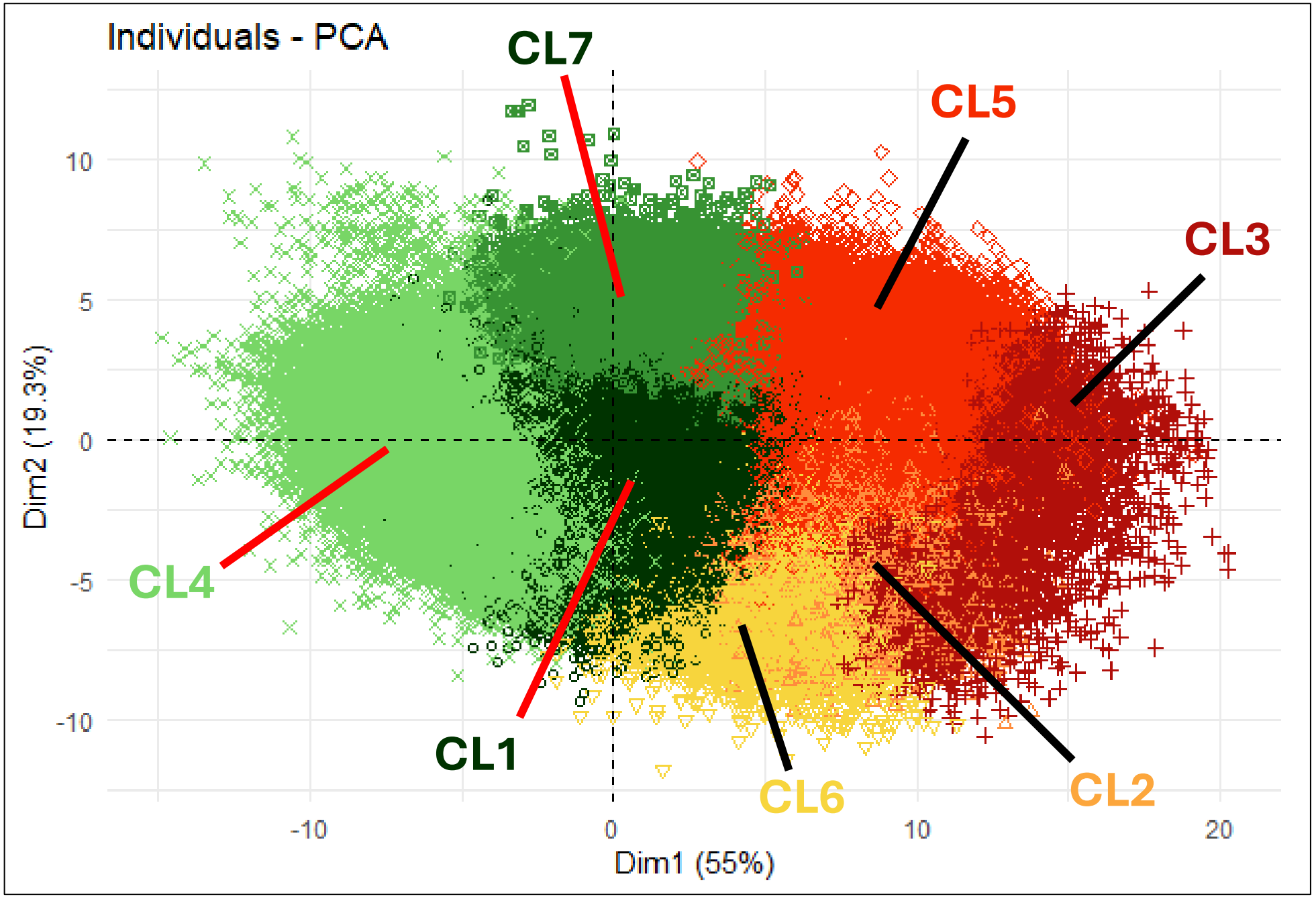
- **774,781 records**
- **2835 farms**
- **Between 2018 and 2021**

Selected Subset

- **27,322 records**


Individuals - PCA
GH > 3
GH < 3
GH < 2
GH < 1
10
5
0
-5
-10
Dim2 (19.3%)
-10
0
10
20
Dim1 (55%)


Height
0
200
400
600
800
Cluster:
4
7
1
2
6
5
3



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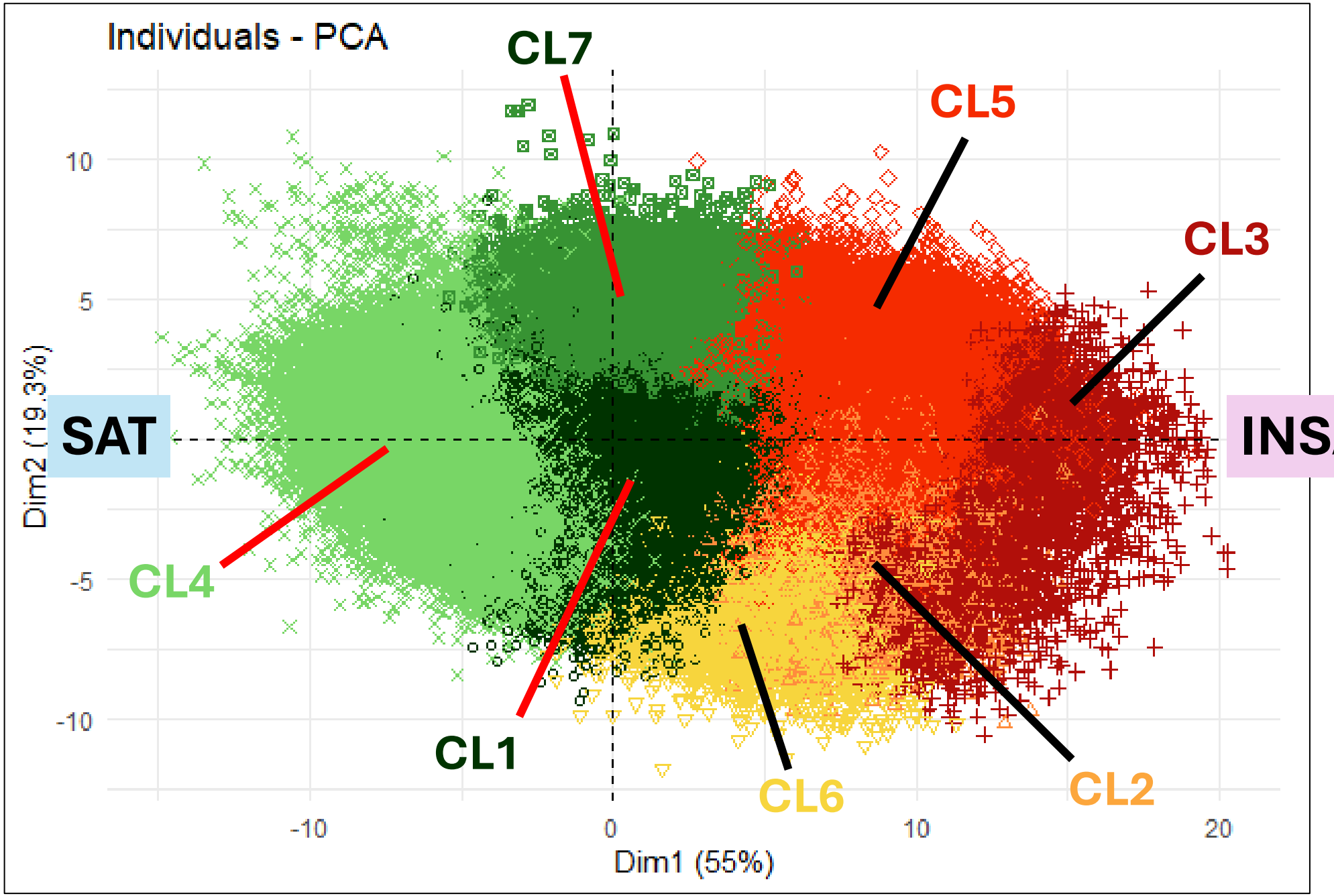

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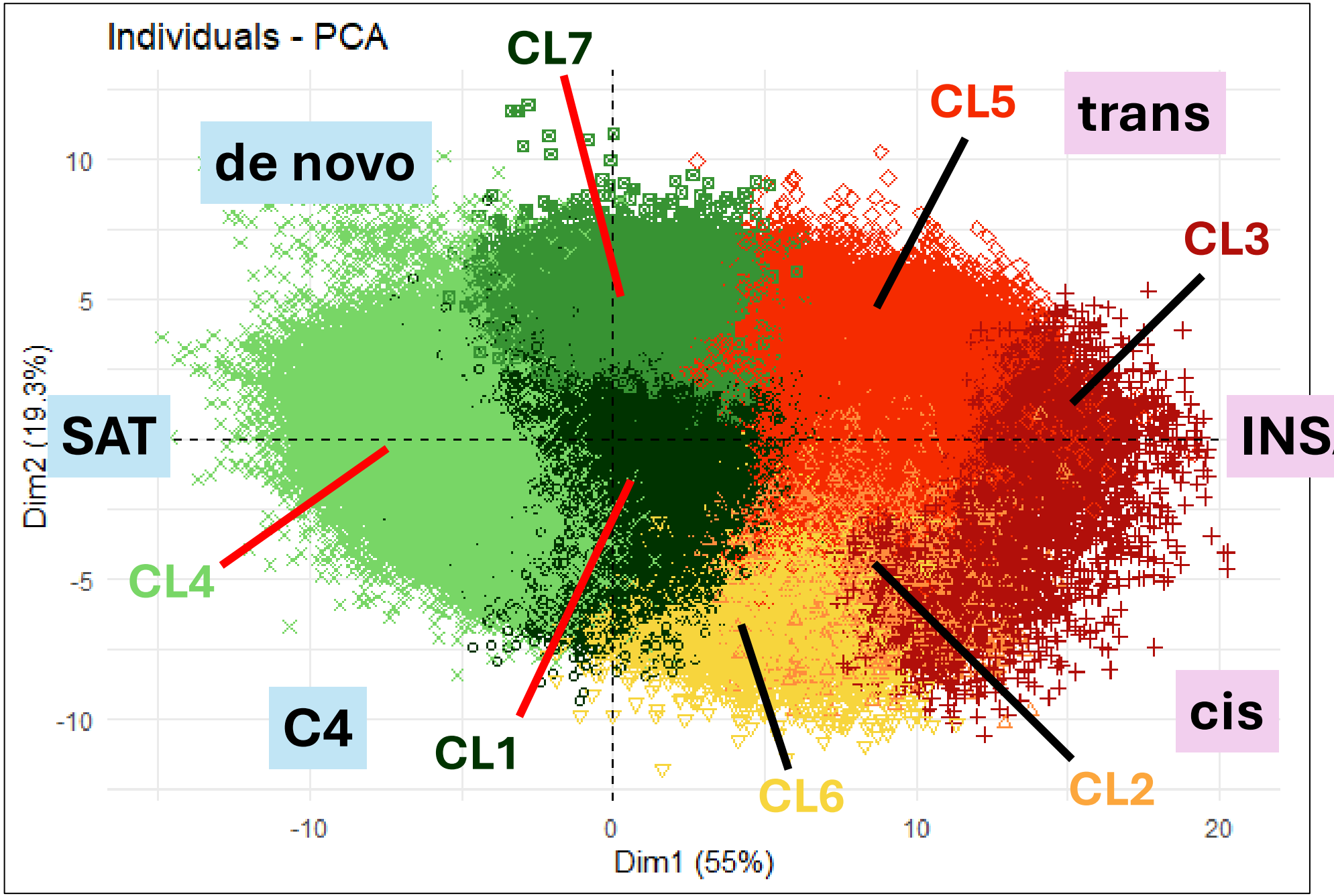

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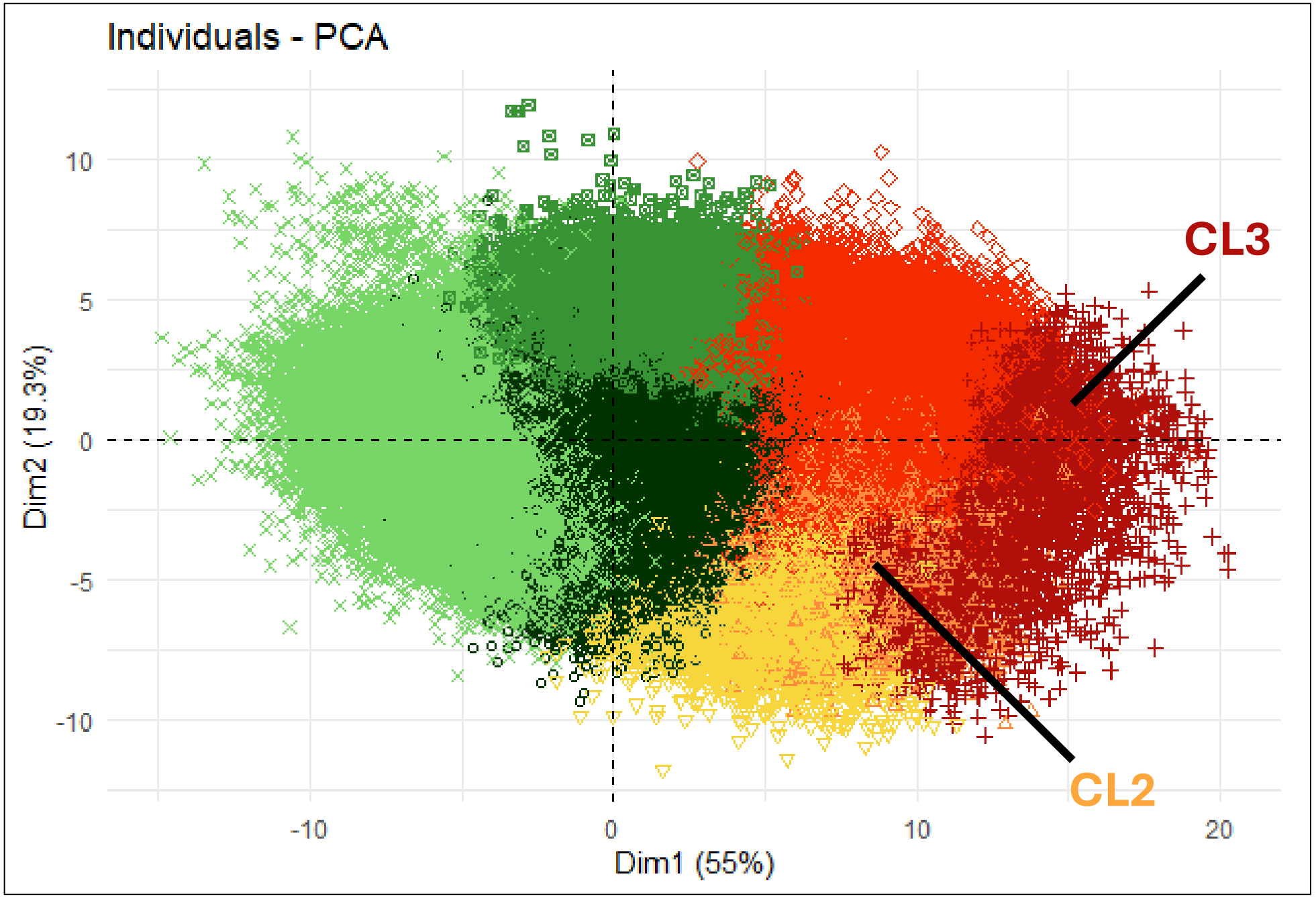

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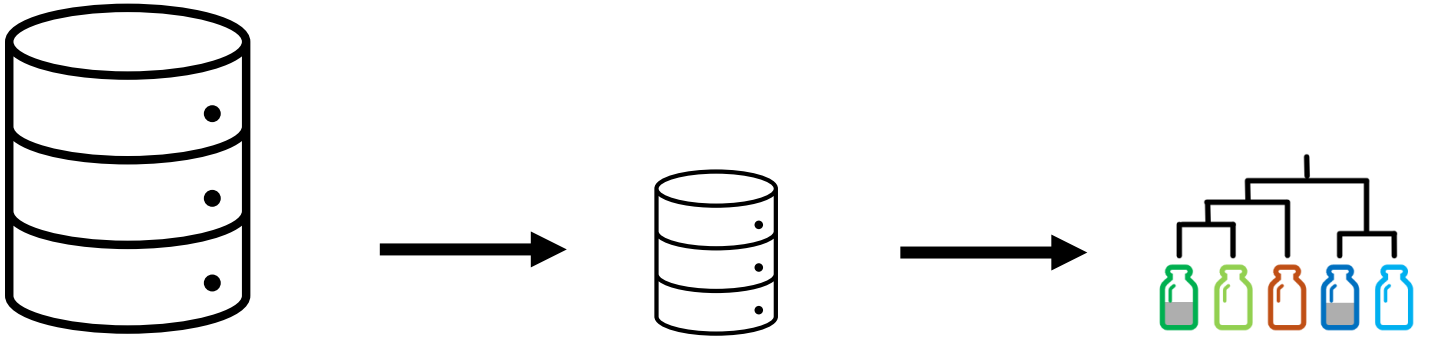
NEFA
BHB

THI
Oleic acid

Prediction models

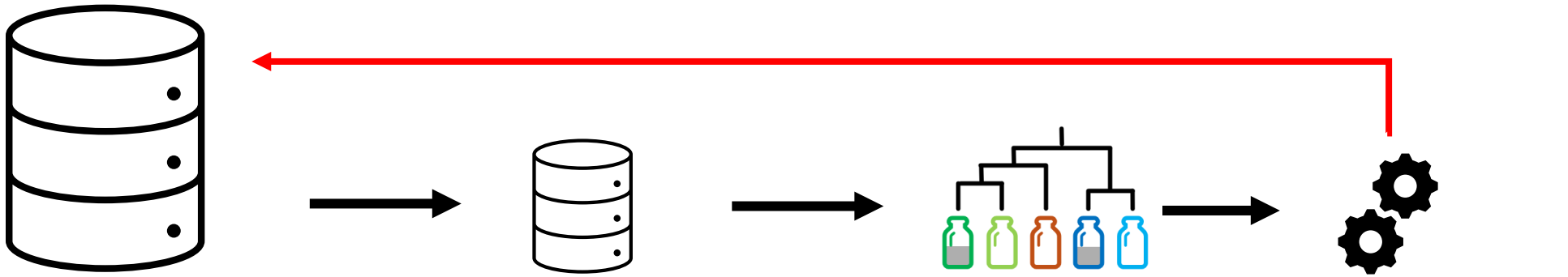


All data

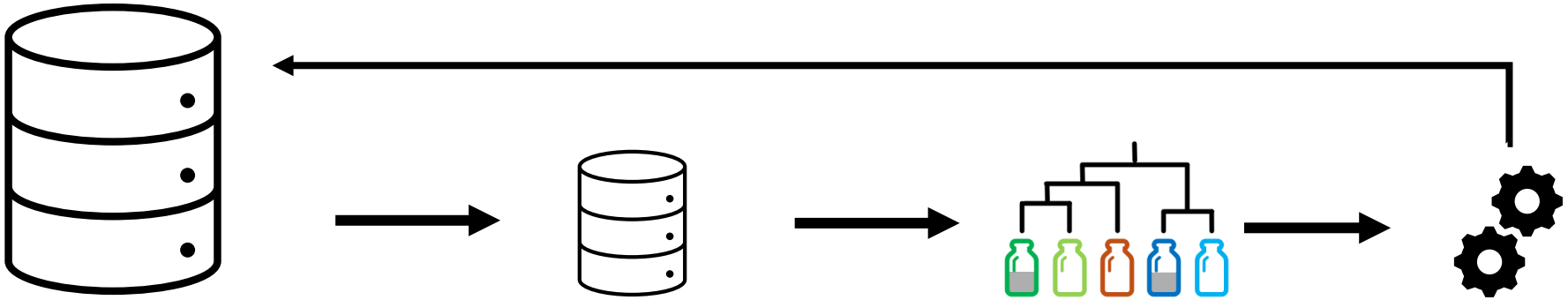
Subset

Cluster Analysis

Prediction models



Prediction models



- **Using a 10-fold cross-validation**
- **From the previous variables** (Accuracy = 91.81%)

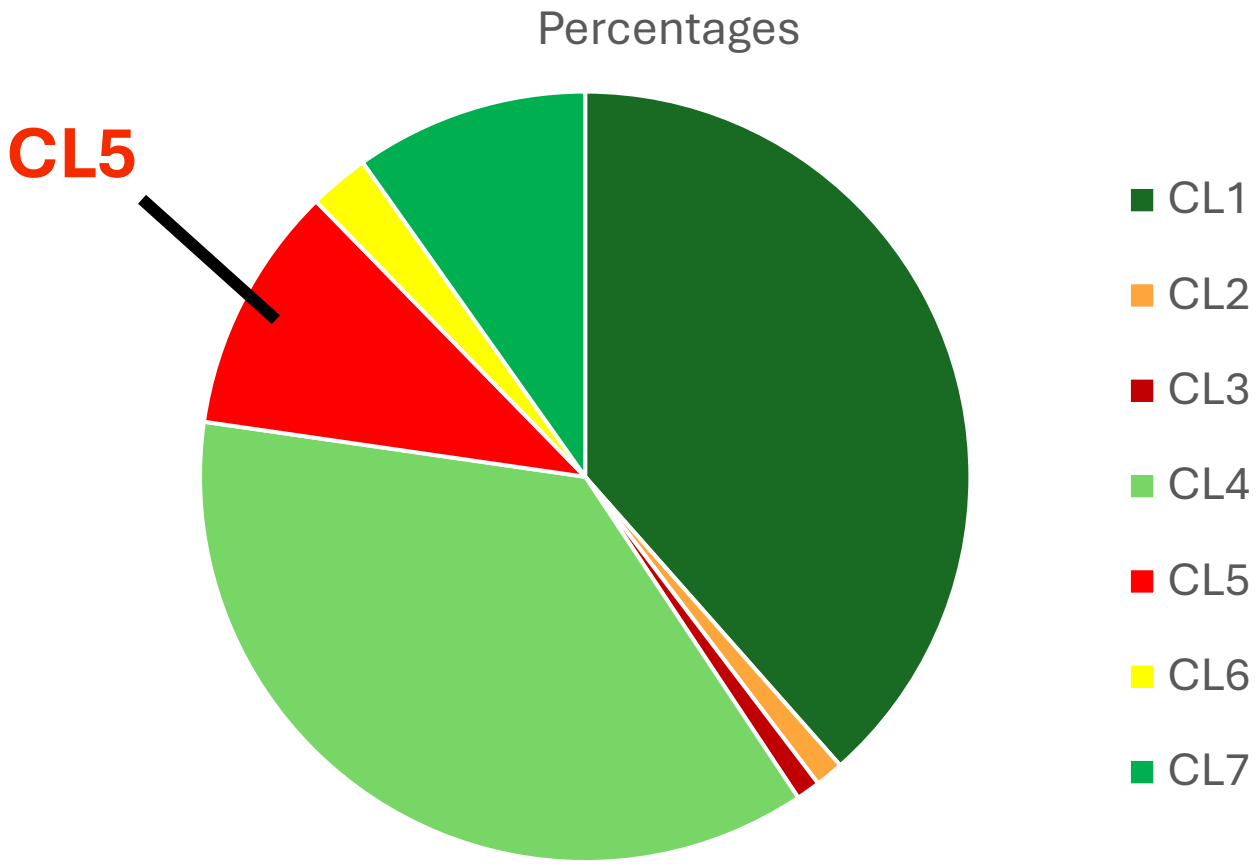
Random Forest model with the 31 variables (FA profile)

- **From the MIR spectra** (Accuracy = 76%)

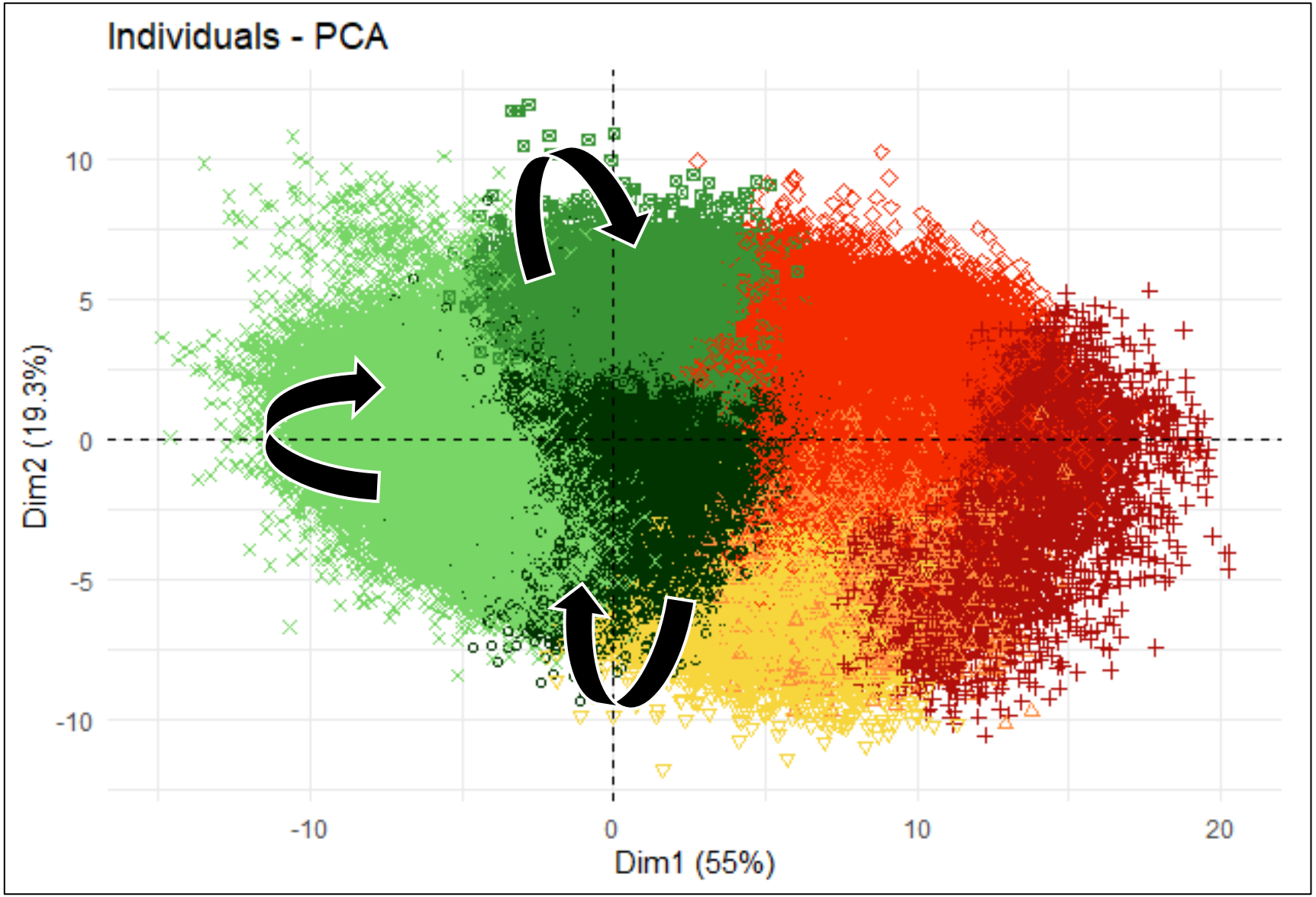
Random Forest model with 289 wavelengths and 1st derivative

- **Insure the transferability**

Prediction models

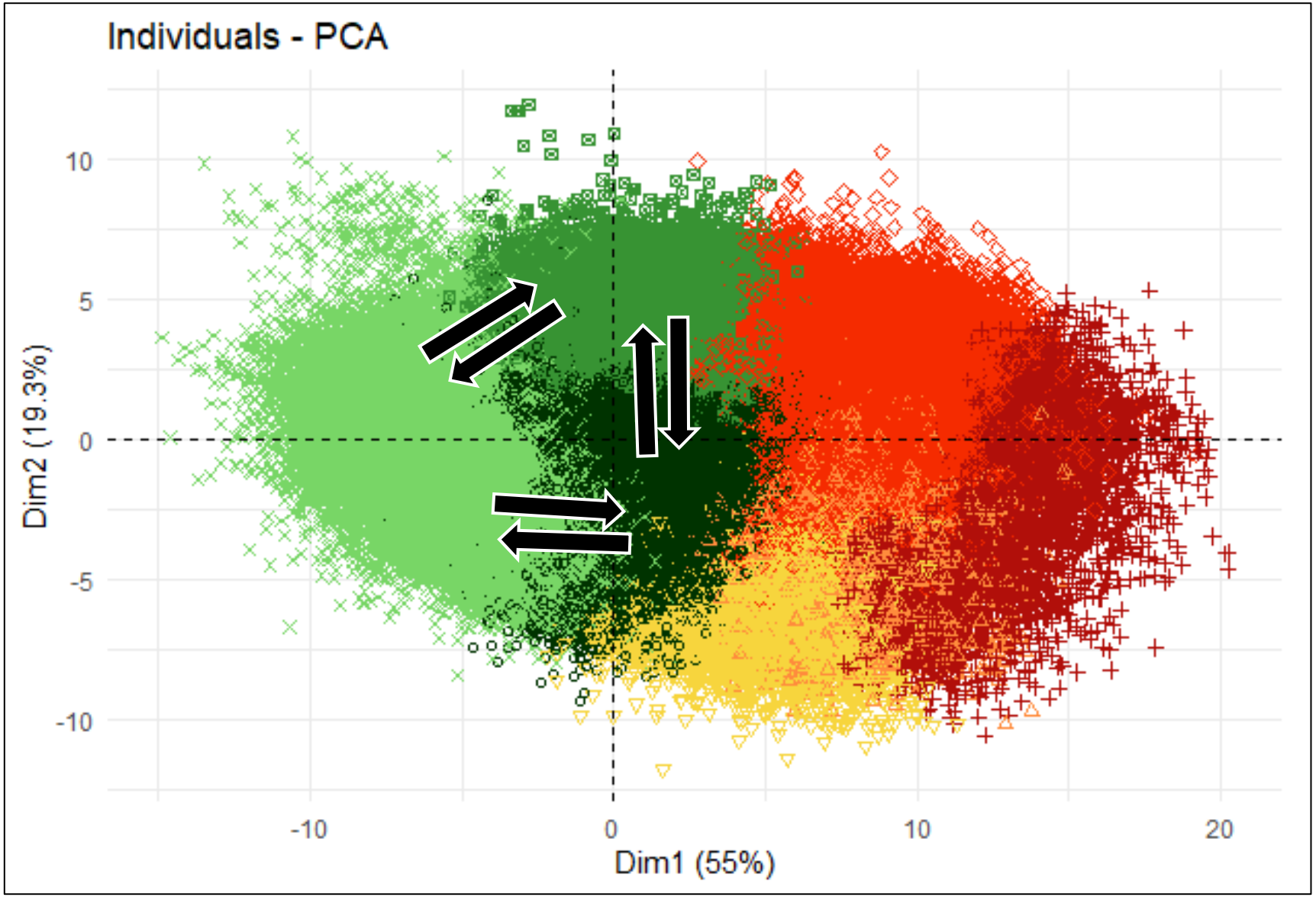


Transition from one cluster to another



~60% to stay in same CL

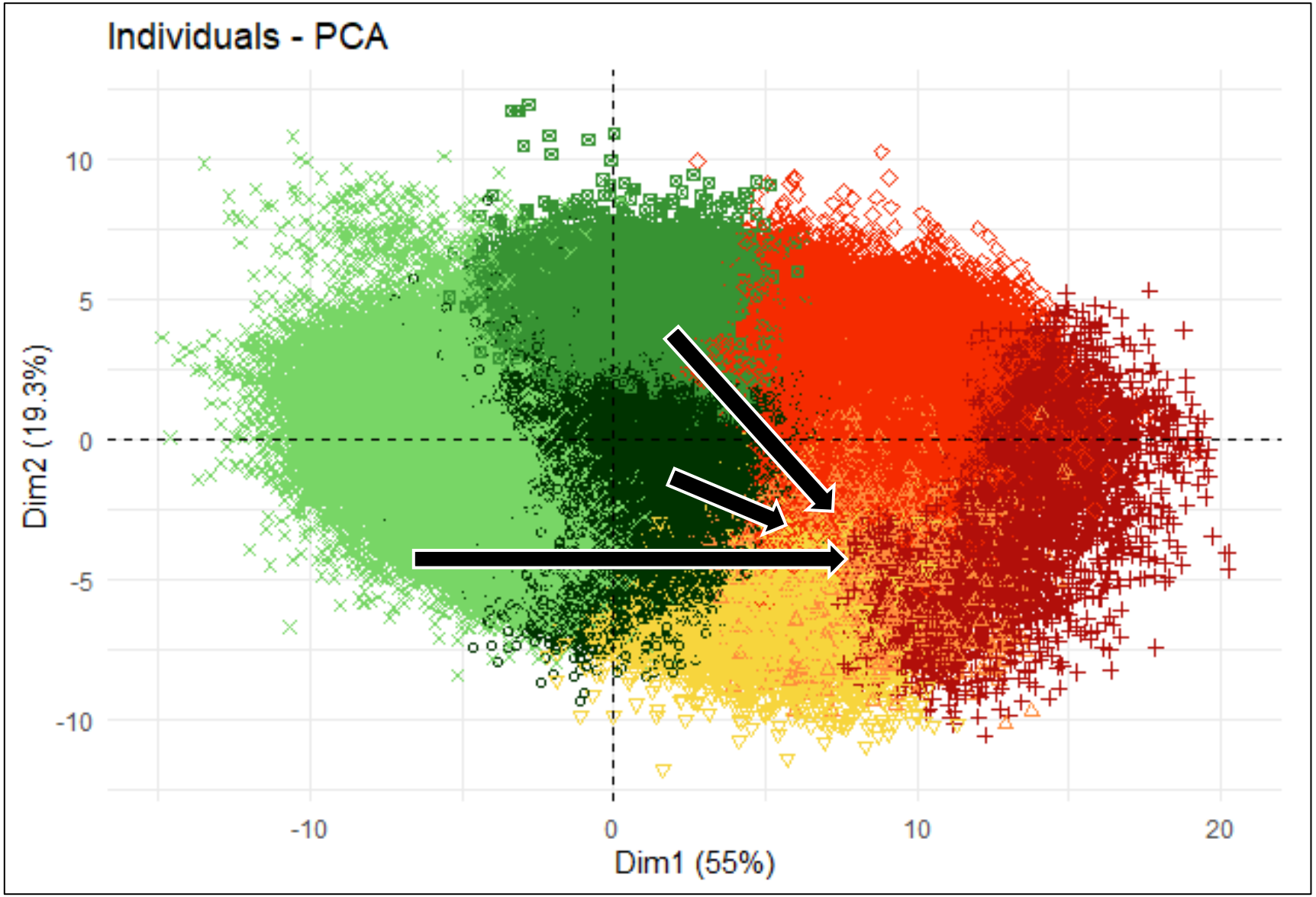
Transition from one cluster to another



~60% to stay in same CL

~30% to move in healthy CL

Transition from one cluster to another

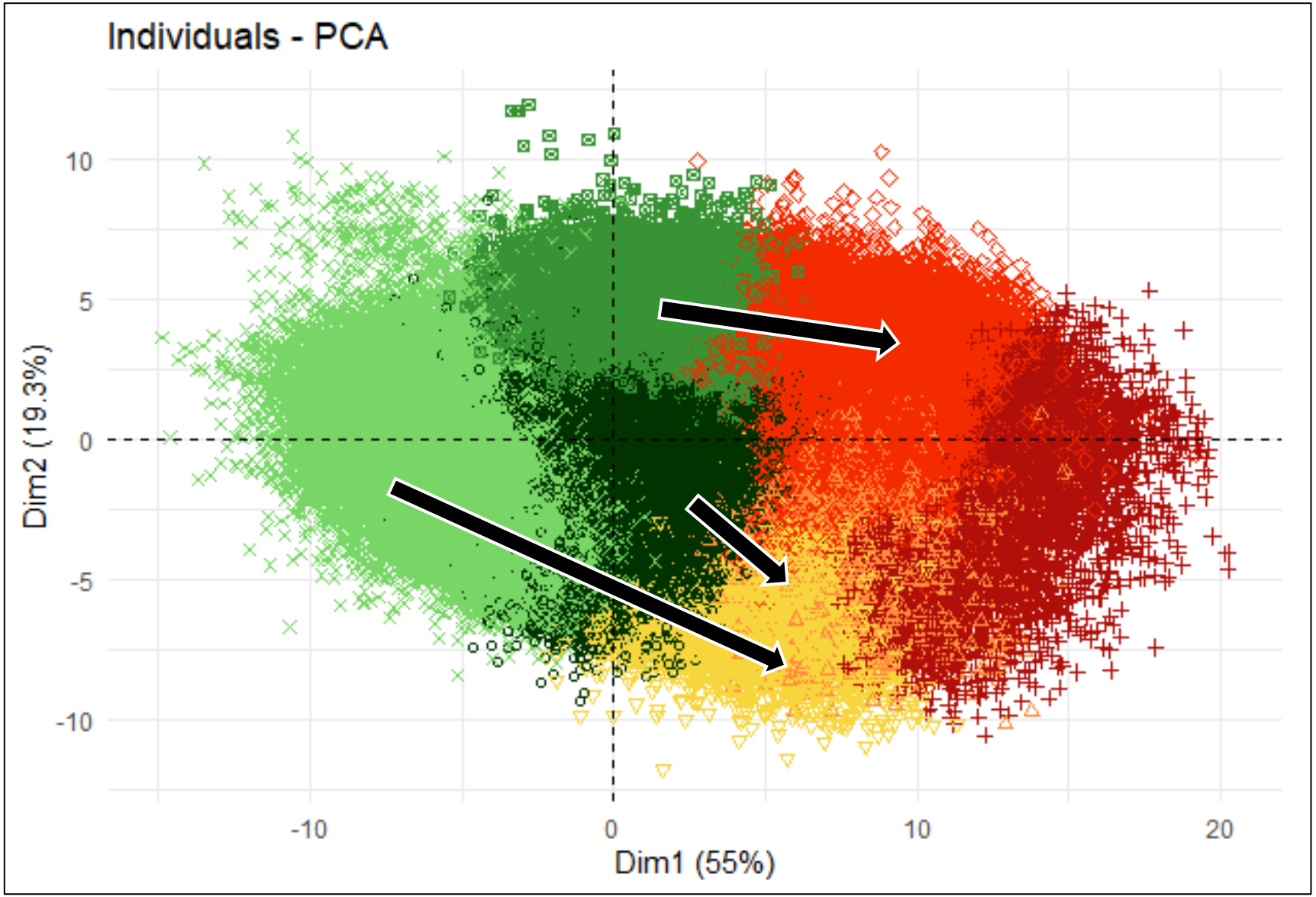


~60% to stay in same CL

~30% to move in healthy CL

2-3% to CL2

Transition from one cluster to another



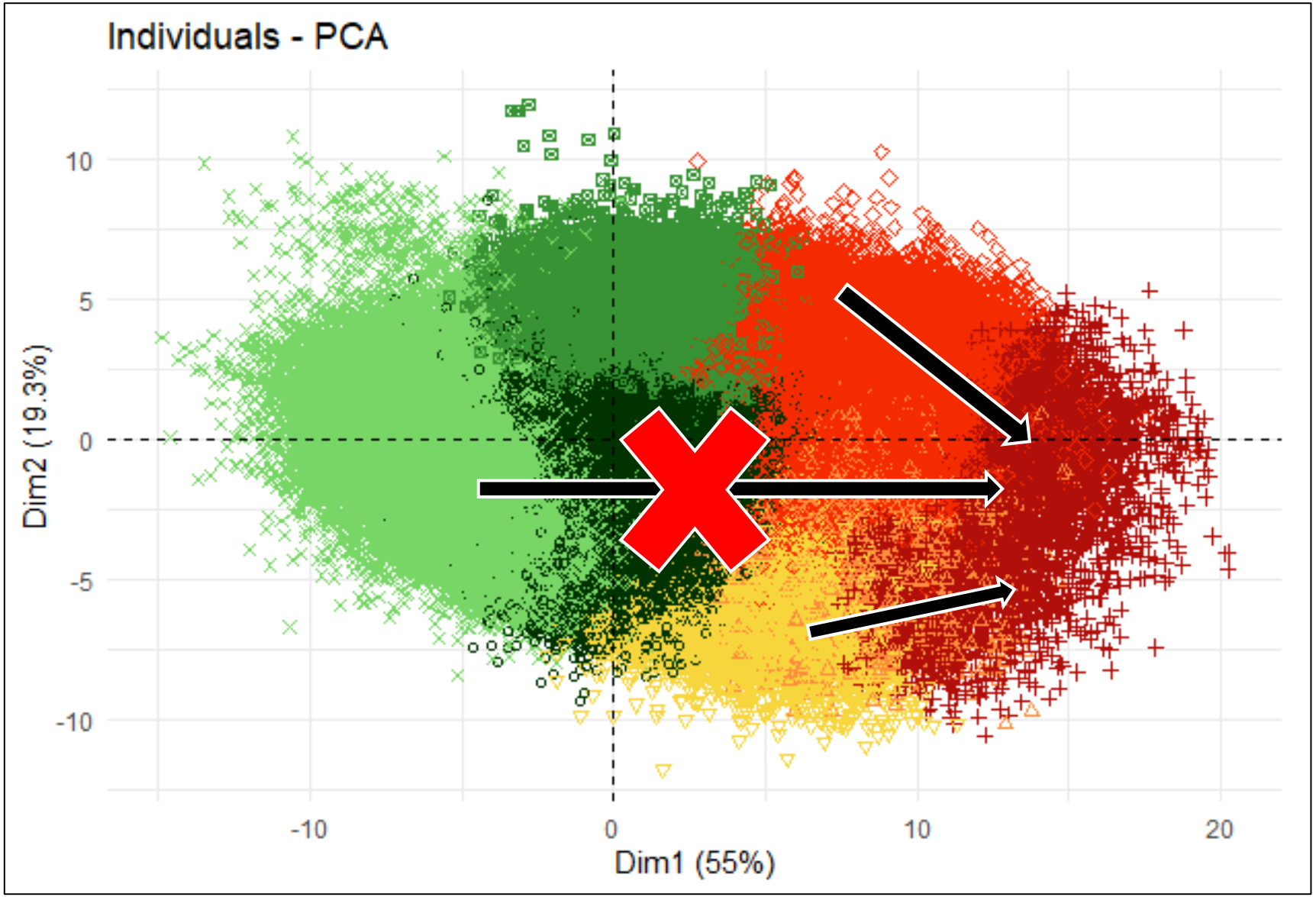
~60% to stay in same CL

~30% to move in healthy CL

2-3% to CL2

7-8% to CL5 & CL6

Transition from one cluster to another



~60% to stay in same CL

~30% to move in healthy CL

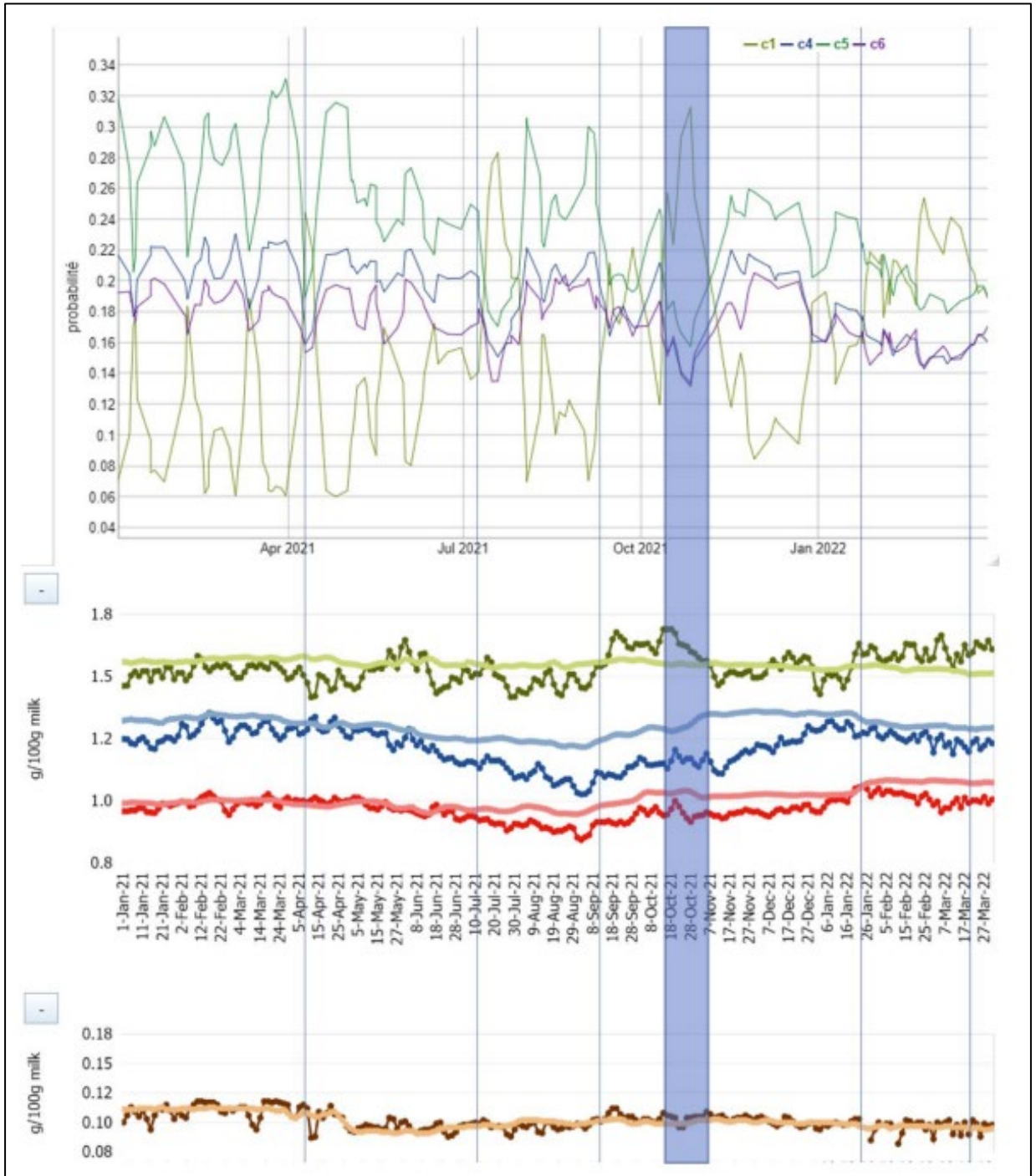
2-3% to CL2

7-8% to CL5 & CL6

But never directly to CL3 !

Time series

- **Looking for switch in probabilities**



(From the work of C. Fastré)

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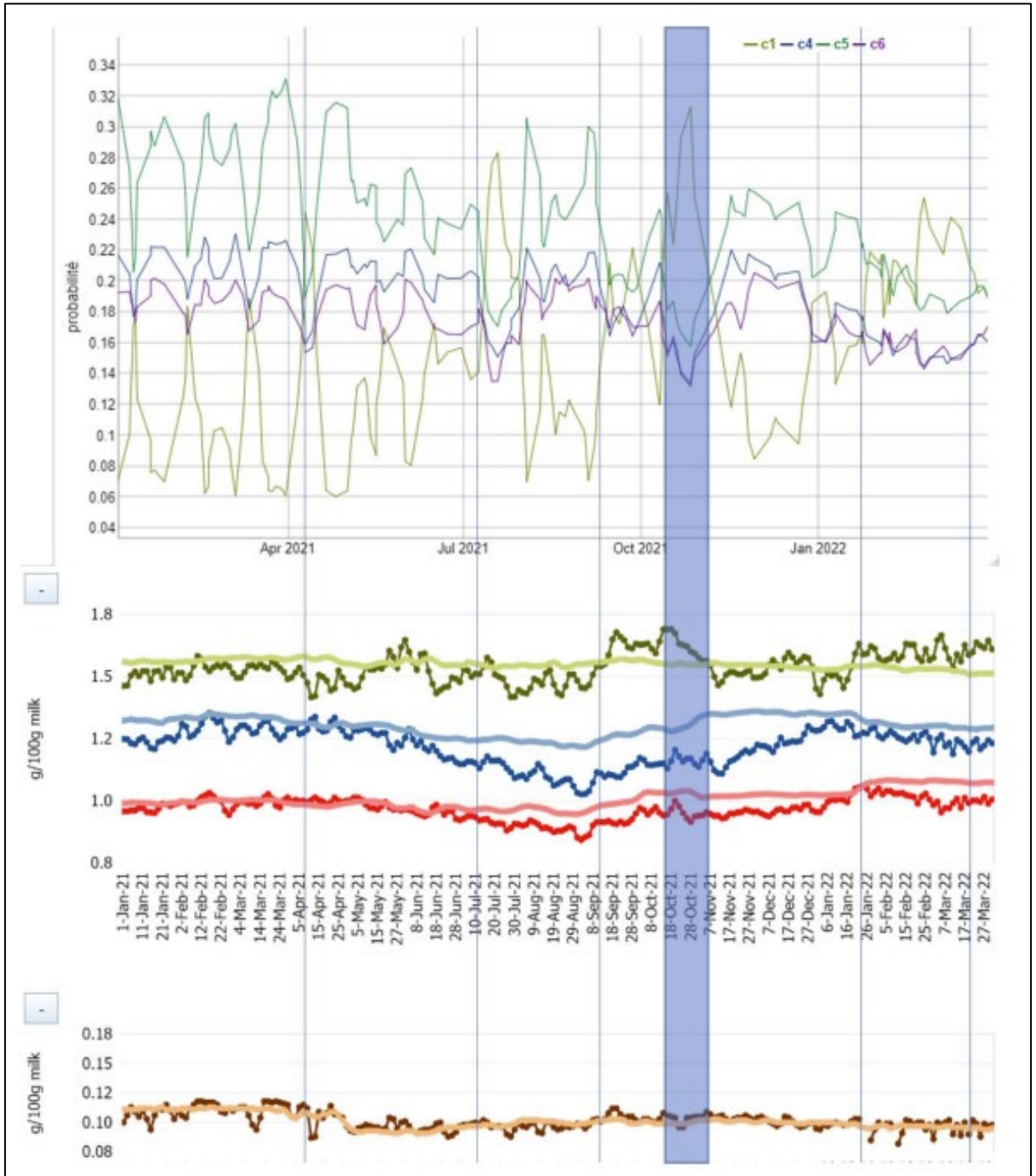
Time series

- **Looking for switch in probabilities**
- **Need on-field validation to assess the relevancy…**



(From the work of C. Fastré)

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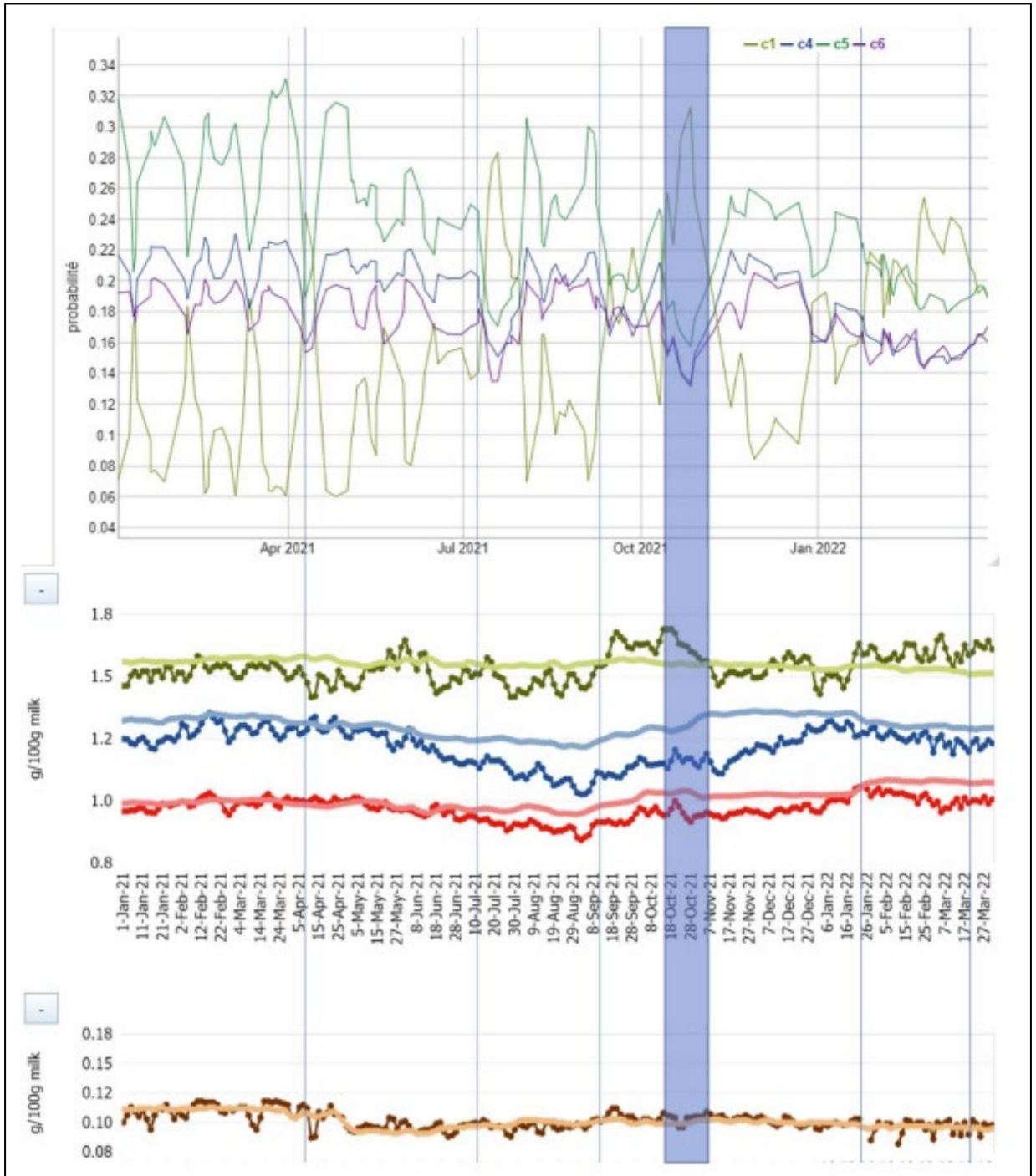
Time series

- **Looking for switch in probabilities**
- **Need on-field validation to assess the relevancy…**
- **And usefulness for the farmer !**



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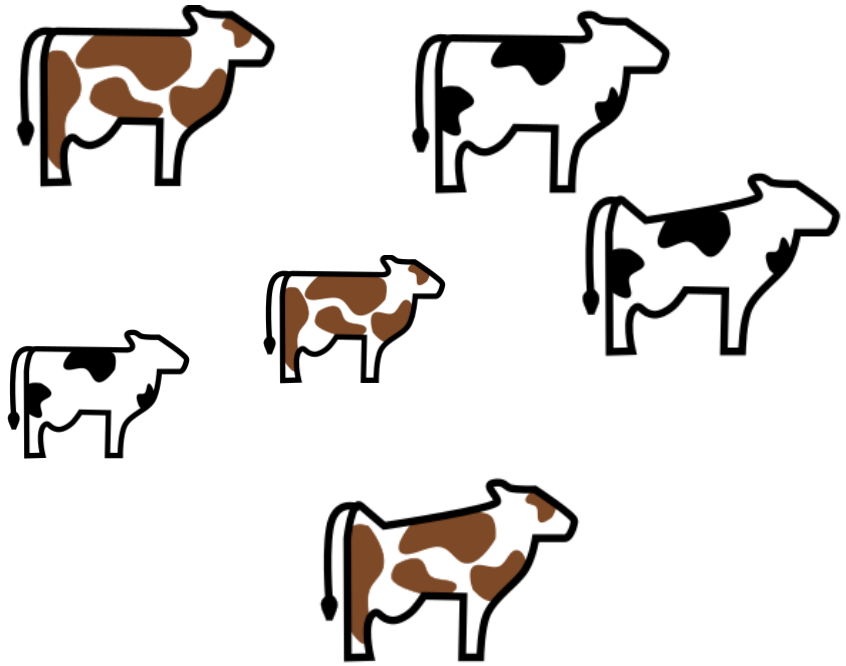
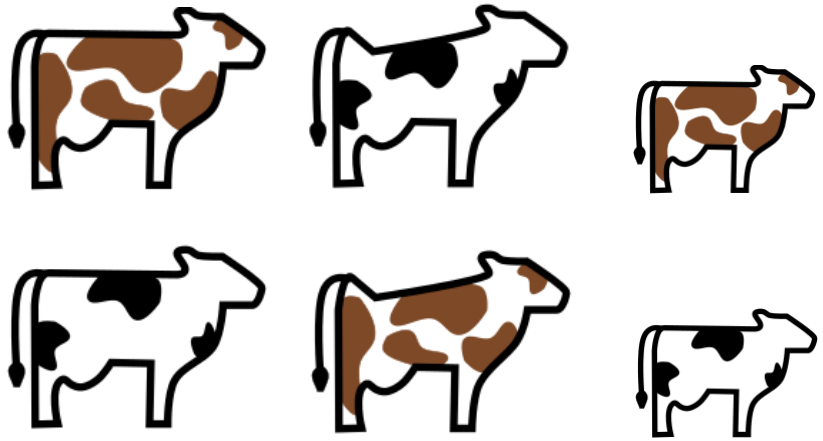
Thanks to all the contributors for their support

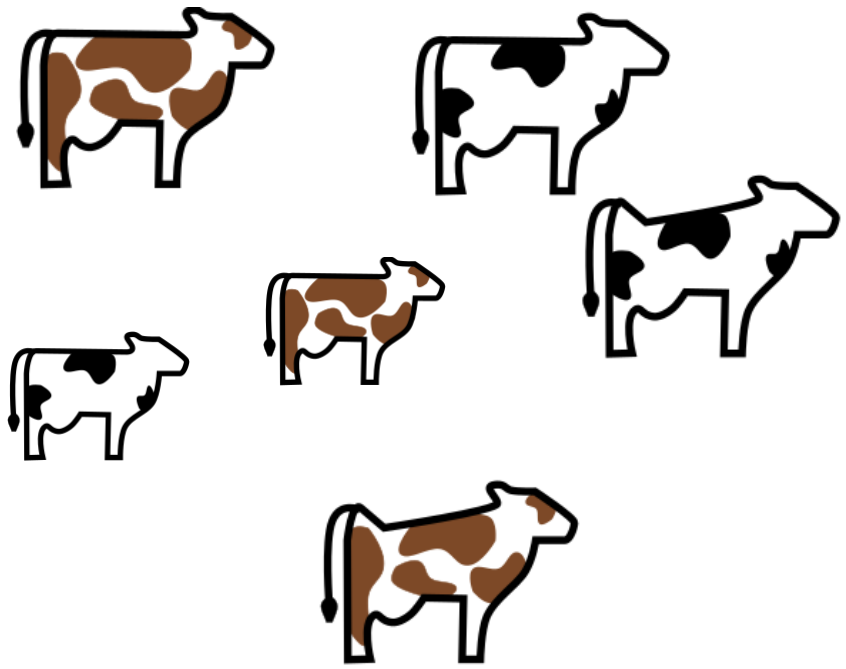
Contact : Sébastien Franceschini
sfranceschini@uliege.be

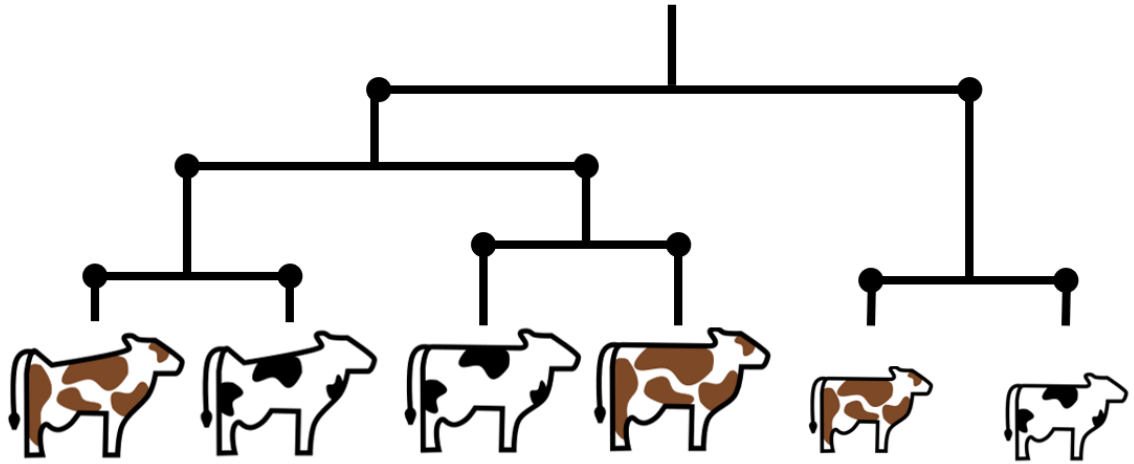
Unsupervised methodology 1

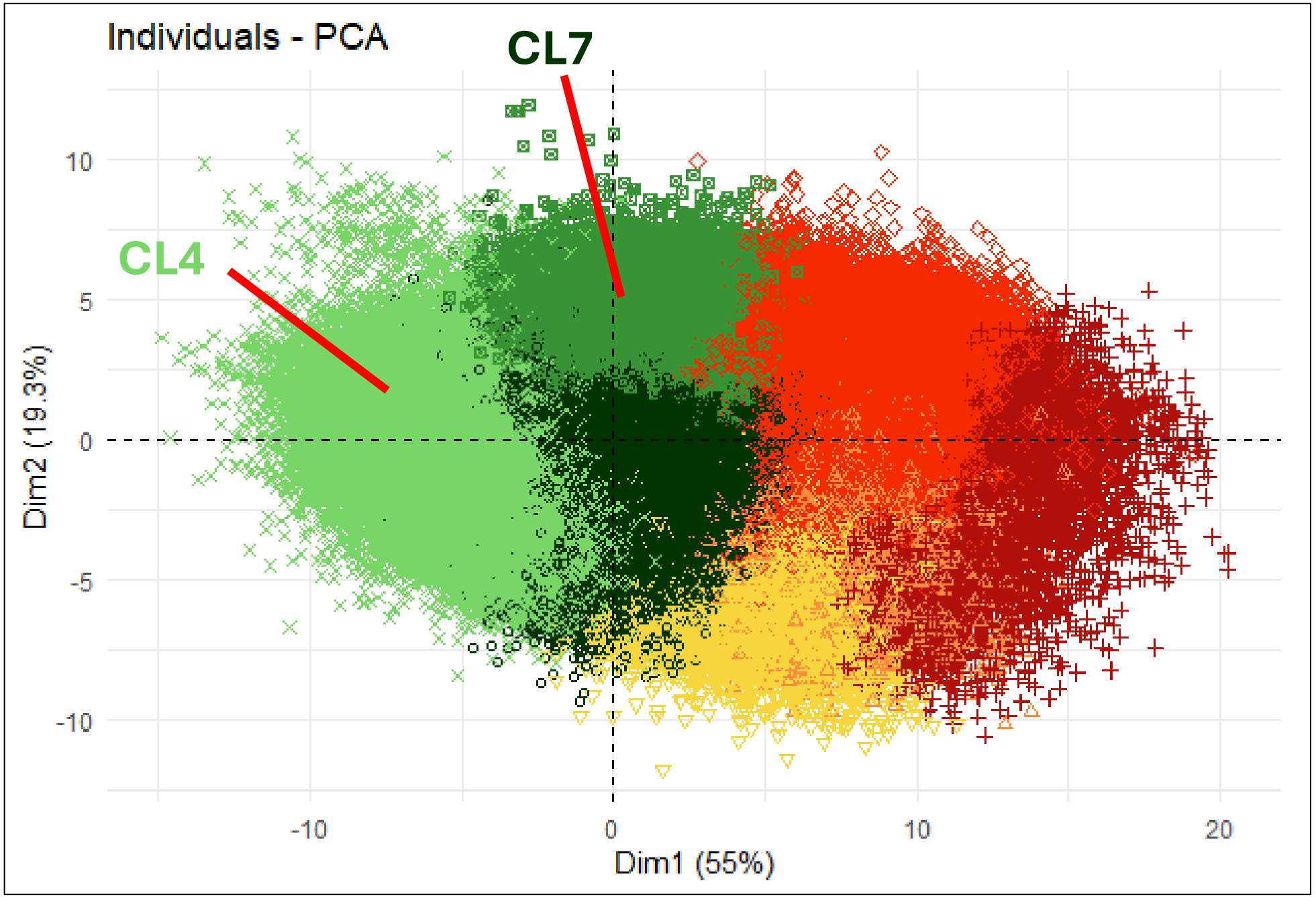




Unsupervised methodology 1







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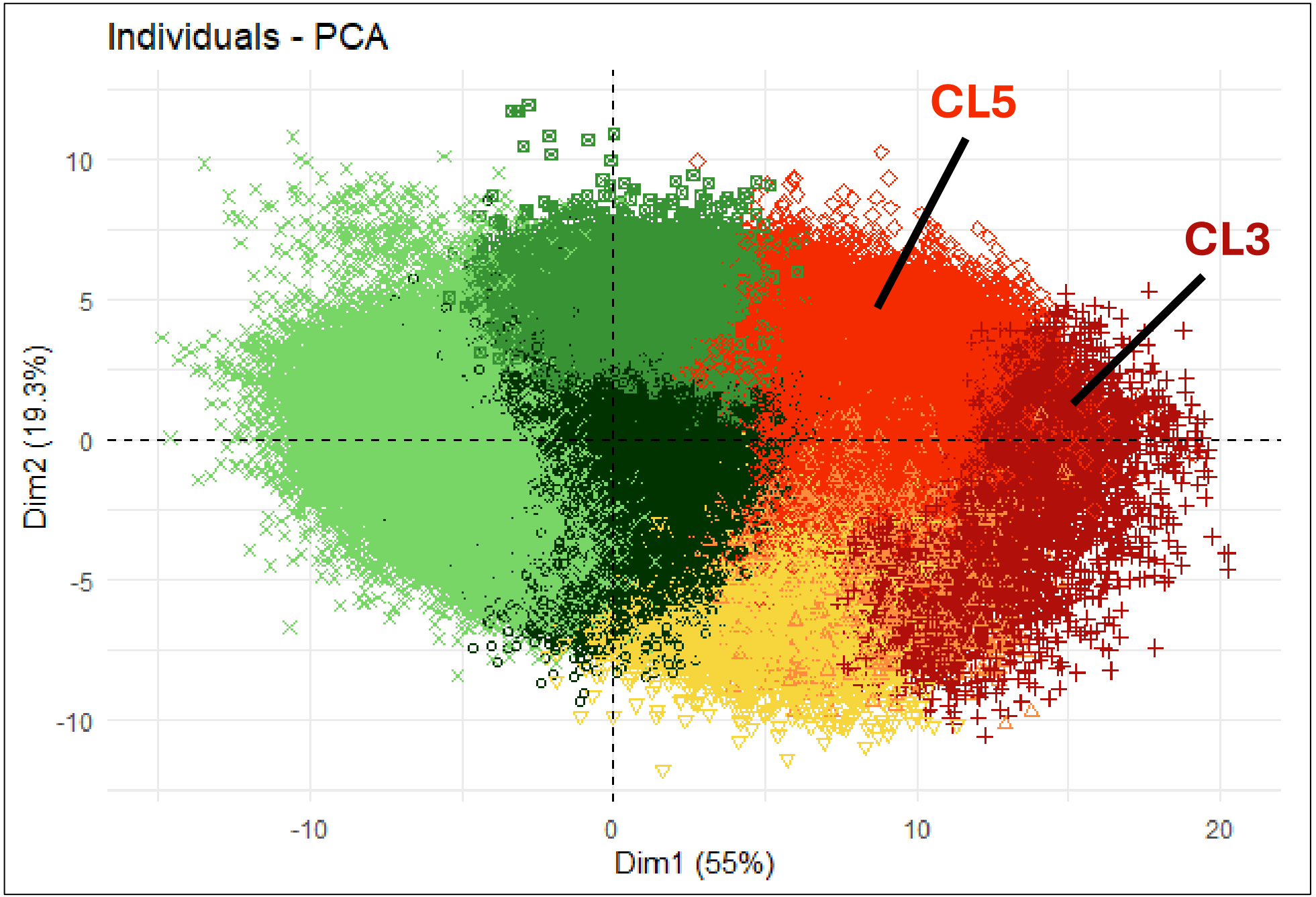
- SAT
- De novo
- C14
- PROT



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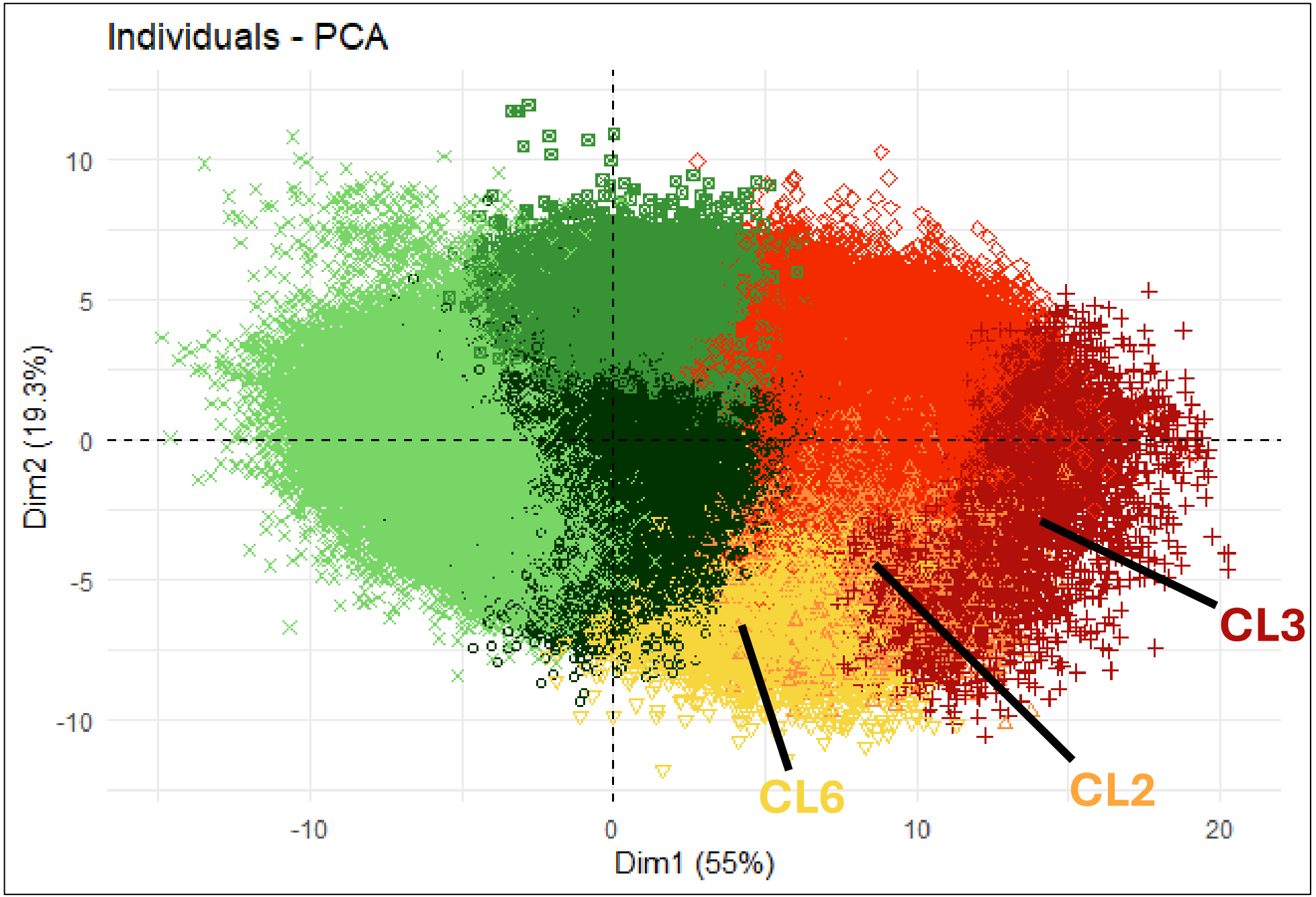
- **Preformed**
- **TRANS**
- **INSAT**



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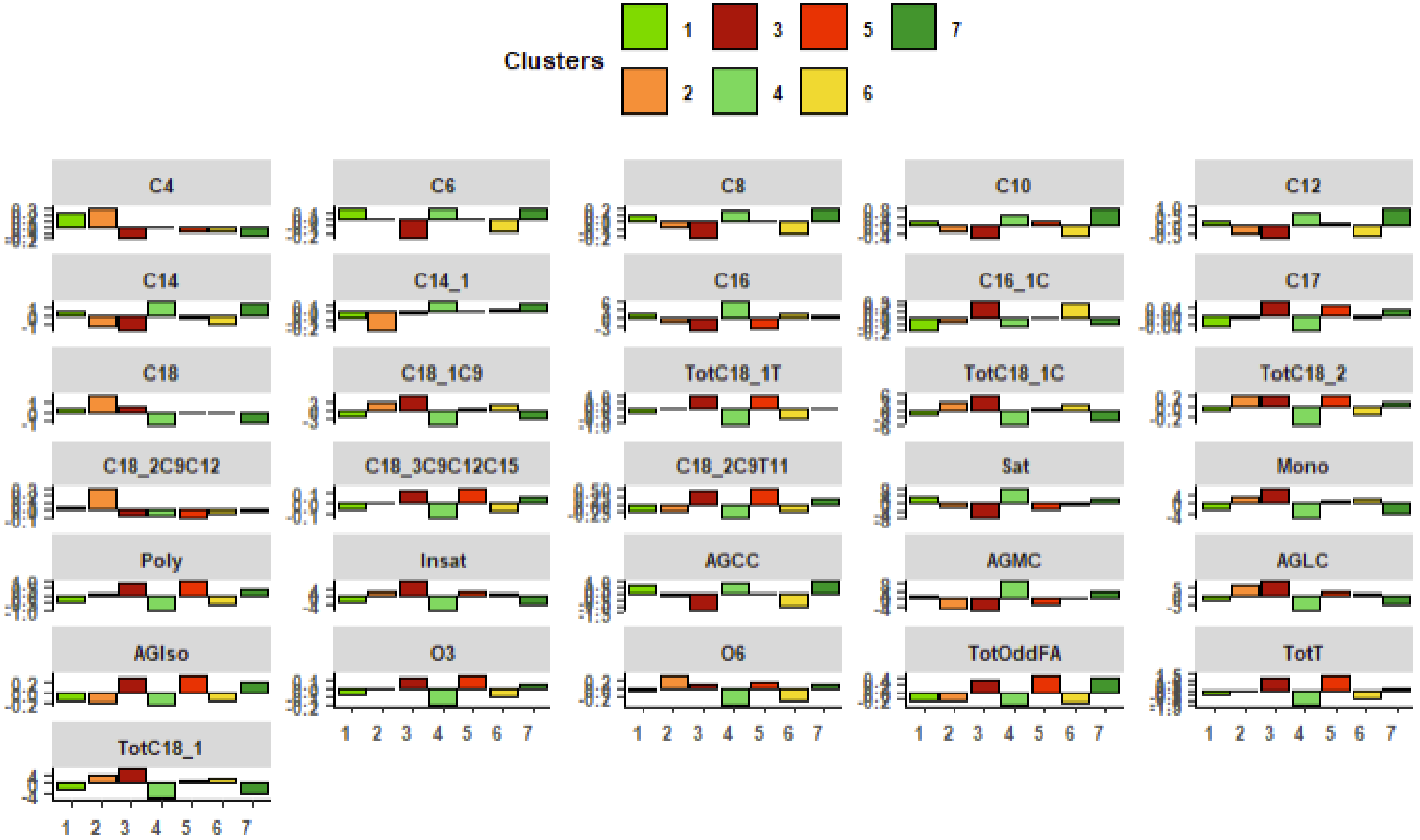
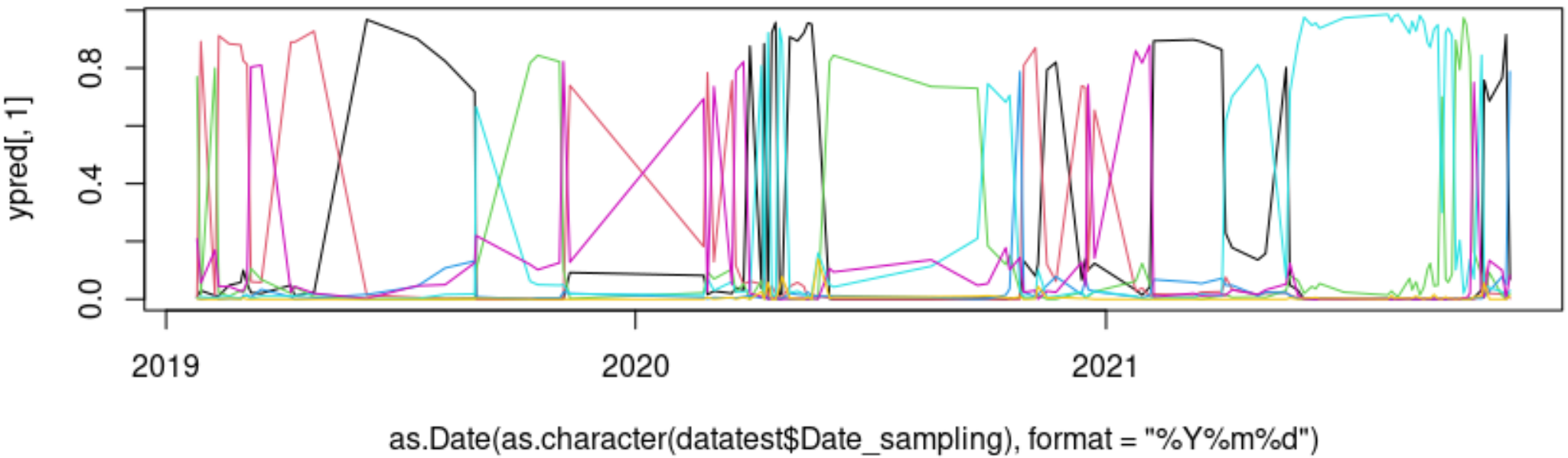
- **Preformed**
- **CIS**
- **INSAT**


Clusters
1
2
3
4
5
6
7
C4
C6
C8
C10
C12
C14
C14_1
C16
C16_1C
C17
C18
C18_1C9
TotC18_1T
TotC18_1C
TotC18_2
C18_2C9C12
C18_3C9C12C15
C18_2C9T11
Sat
Mono
Poly
Insat
AGCC
AGMC
AGLC
AGIso
O3
O6
TotOddFA
TotT
TotC18_1
1 2 3 4 5 6 7

Relation with month

	c1	c2	c3	c4	c5	c6	c7
janvier	0.37	0.01	0.00	0.53	0.00	0.01	0.08
février	0.44	0.01	0.00	0.53	0.00	0.01	0.00
mars	0.41	0.02	0.00	0.50	0.01	0.02	0.04
avril	0.50	0.03	0.00	0.34	0.06	0.01	0.06
mai	0.47	0.01	0.00	0.32	0.07	0.01	0.11
juin	0.49	0.01	0.01	0.39	0.04	0.04	0.02
juillet	0.50	0.02	0.02	0.32	0.07	0.06	0.01
août	0.39	0.01	0.02	0.29	0.19	0.04	0.06
septembre	0.30	0.01	0.02	0.27	0.26	0.03	0.11
octobre	0.25	0.00	0.02	0.24	0.24	0.02	0.22
novembre	0.17	0.00	0.01	0.36	0.15	0.01	0.30
décembre	0.30	0.00	0.00	0.43	0.02	0.01	0.24

Time series


ypred[, 1]
0.0
0.4
0.8
2019
2020
2021
as.Date(as.character(datatest$Date_sampling), format = "%Y%m%d")