Are GPS sensors suitable to ensure the traceability of dairy cows on pastures?

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INSTITUT DE L'ELEVAGE idele

CATTLE CHAIN

Horizon 2020
European Union Funding
for Research & Innovation

Consumers' expectations regarding animal welfare

Expectation of more naturalness
(free range access & pasture)

Development of Pasture milk labels

120 d

150 d

200 d

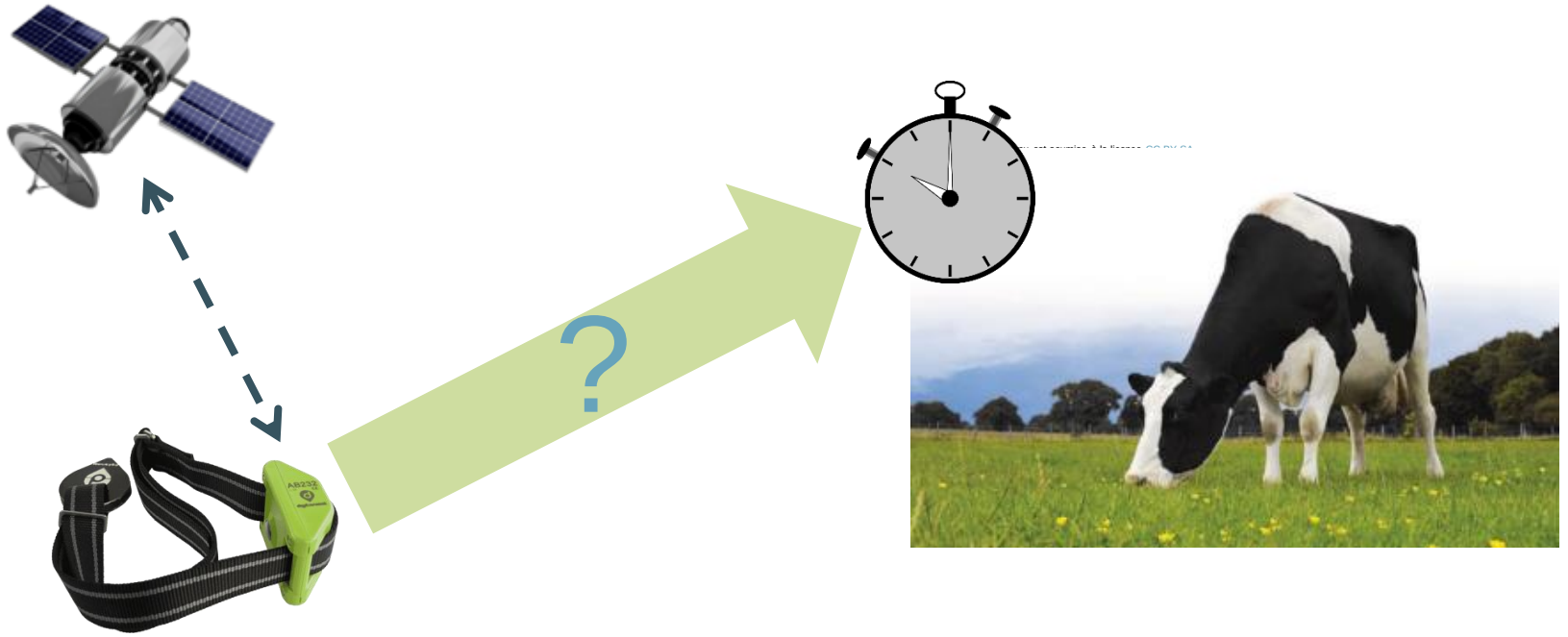
Several specifications regarding the label but mostly :

- at least 6 h/d grazing
- at least 120 d/year grazing
- grazing is more defined as « outdoor access » than intake of grass

Objective of the project

How can we **automatise** the compliance checking of “grazing milk” specifications with the use of embedded GPS sensors ?

Especially the **time cows spend outside (TOut)** ?



M&M: the global concept

Algorithm A

GNSS data

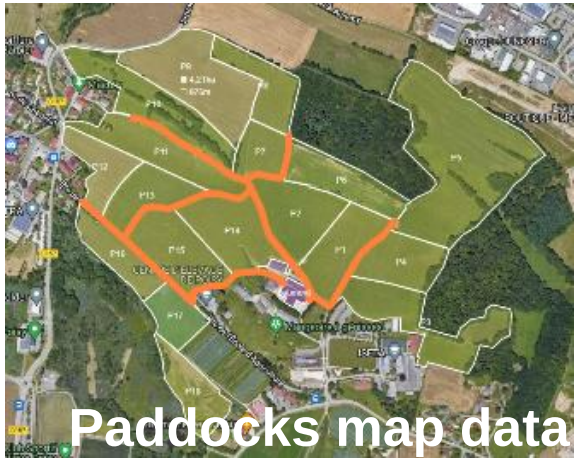
Automatic detection of the barn

TOut and other outputs

Algorithm B

GNSS data

+



Positionning in a paddock + Kinetic corrections

TOut and other outputs

M&M : Animals and sensors

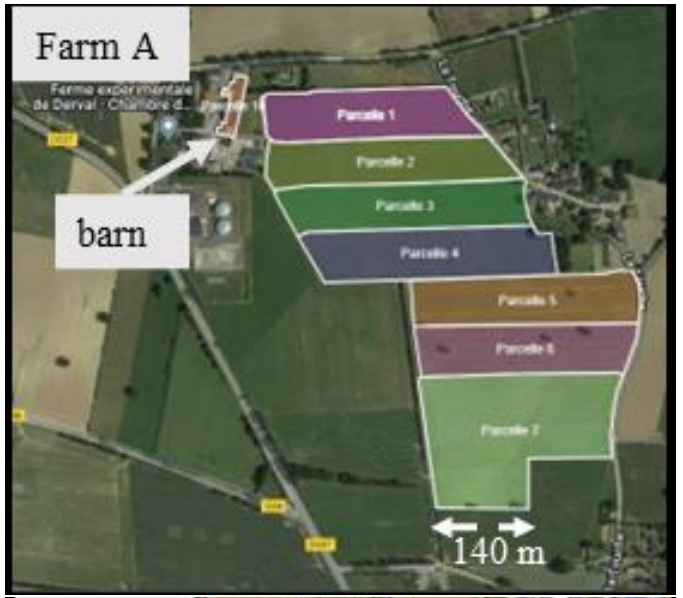
Time spent outdoor monitored on 2 experimental farms (3 datasets) …

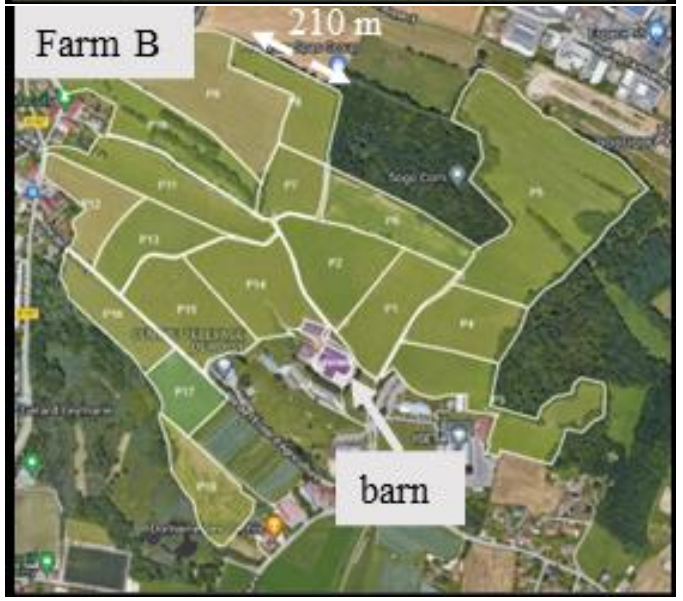
Trial Name	A-2019	B-2019	B-2020
Farm Name	A	B	B
Trial period (dmy)	03/04/2019 – 05/05/2019	19/07/2019 – 31/08/2019	22/07/2020 – 16/09/2020
Number of cows in the herd	70	85	85
Number of cows equipped with GPS sensor	8	9	9
Trial duration (days)	37	36	48
Access to pastures	Mostly free	Limited	Limited

… Thanks to digitanimal GNSS sensor.

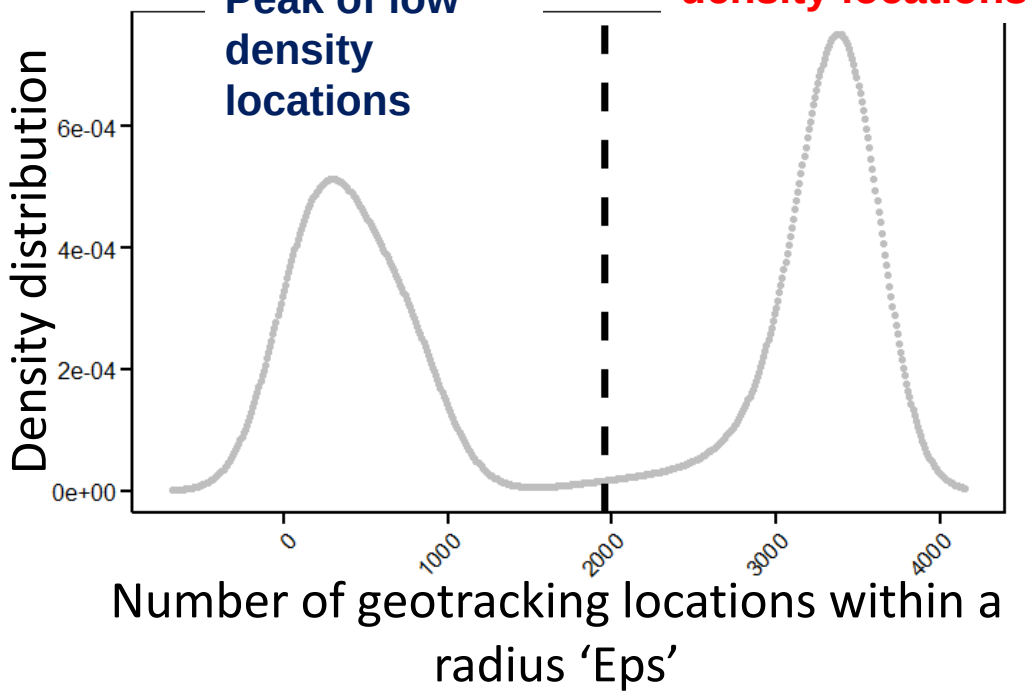
1 geotracking position every 11 min

Reference Time spent outdoor recorded with RFID identification at the gate (farm A) or manually (farm B)



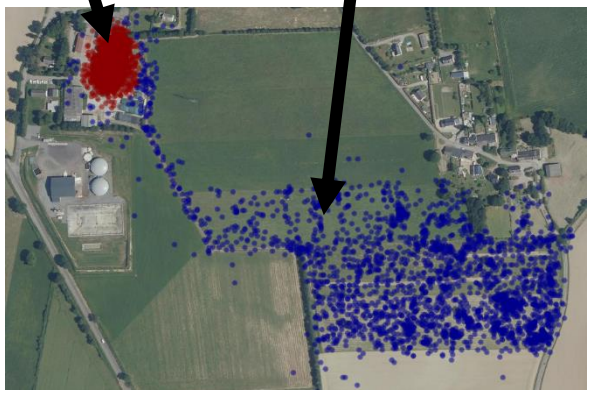


M&M : Algorithm A (a density-based algorithm)



« barn » locations

« pastures » locations



DBSCAN (Hahsler et al., 2019)

TOut = nbr of pastures locations * interval between 2 GNSS data (11min)

See *Lebreton et al. (2022)* for more details on the methodology

M&M : Algorithm B

Inputs

GNSS data

Paddocks map data

Is the cow location in a « paddock » polygon (P) or in the « barn » polygon (B) ?

Outputs

TOut

TOut = nbr of pastures locations * interval between 2 GNSS data (11min)

Results : Grazing time estimation

Farm	Daily average TOut estimated by algorithm B
+ A	RMSE = 17 min/d (CV = 2.5%)
○ B 2019	RMSE = 40 min/d (CV = 3.5%)
△ B 2020	RMSE = 50 min/d (CV = 6.0%)

Algorithm A results available at Lebreton *et al.* (2022)

Are GPS sensors and density-based classification suitable to ensure the traceability of dairy cows on pastures? Part I: Development and validation on experimental farms

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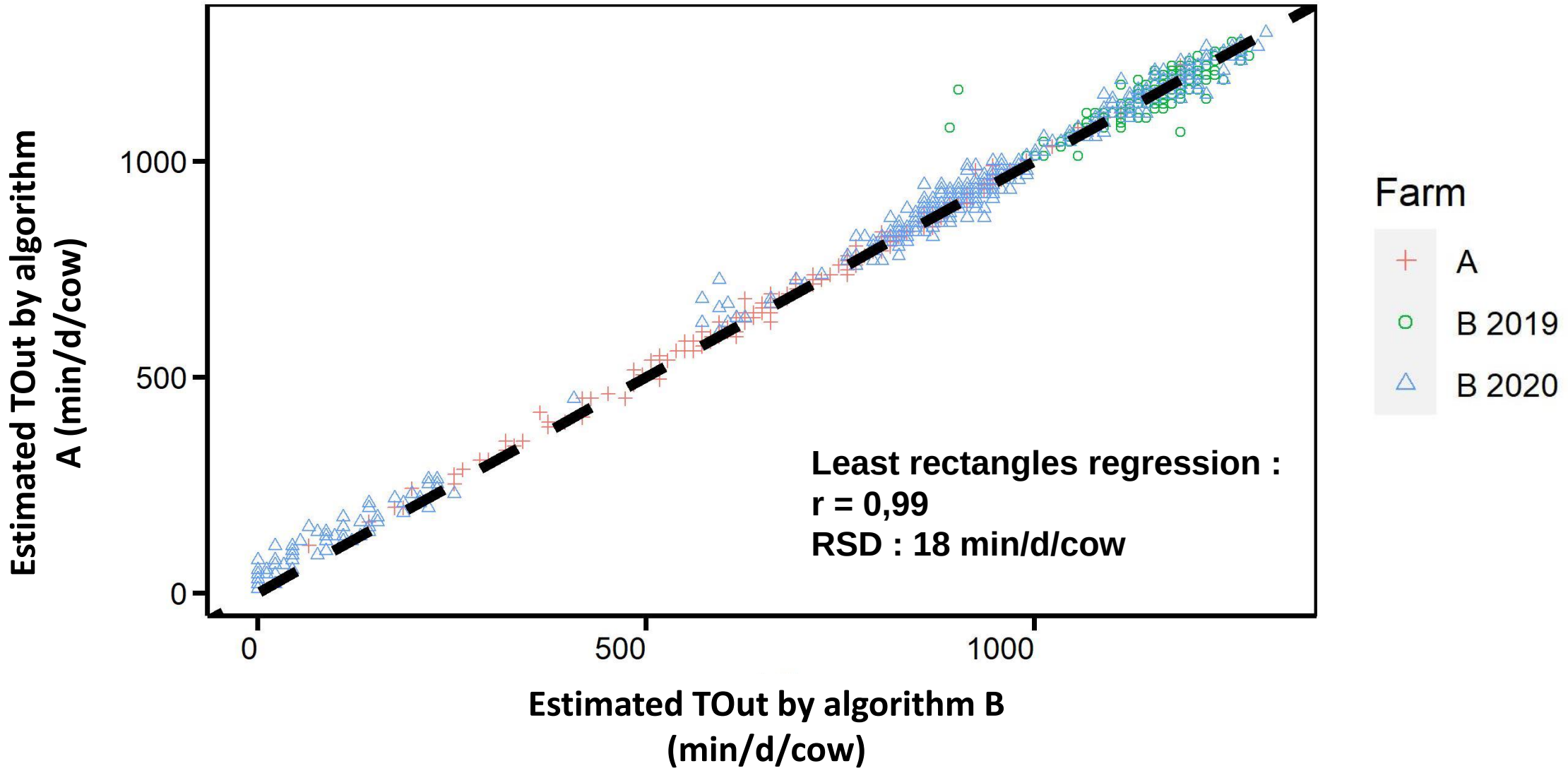
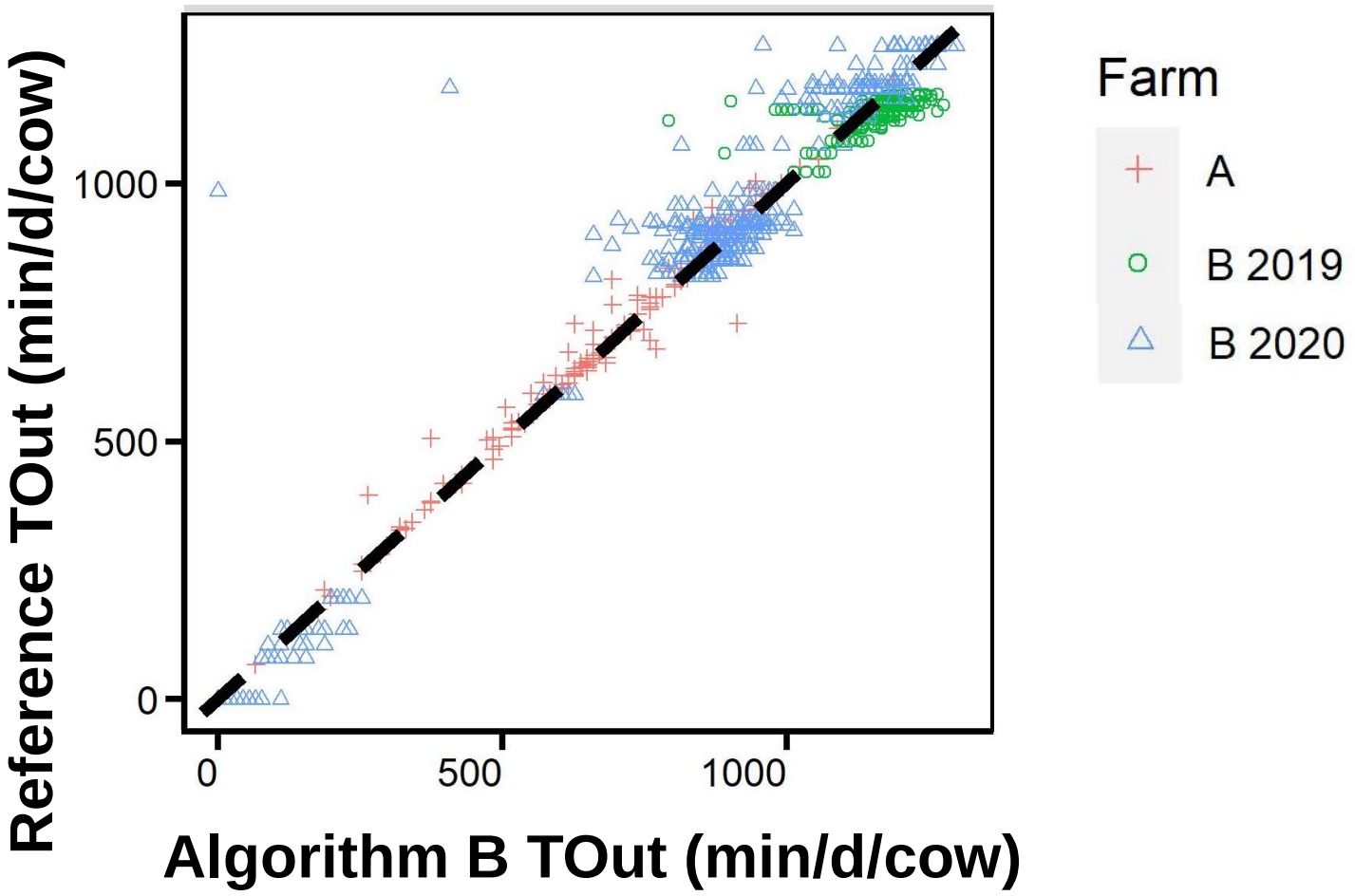
Results : Grazing time estimation



Algorithm B provide similar results than Algorithm A

Results : Grazing time estimation



Daily average TOut estimated by algorithm B
RMSE = 19 min/d (CV = 2.8%)
RMSE = 39 min/d (CV = 3.4%)
RMSE = 46 min/d (CV = 5.5%)

Average Reference TOut	Average TOut estimated by algorithm B
676 ± 221 min/d	665 ± 220 min/d
1132 ± 31 min/d	1153 ± 62 min/d
835 ± 377 min /d	825 ± 352 min/d

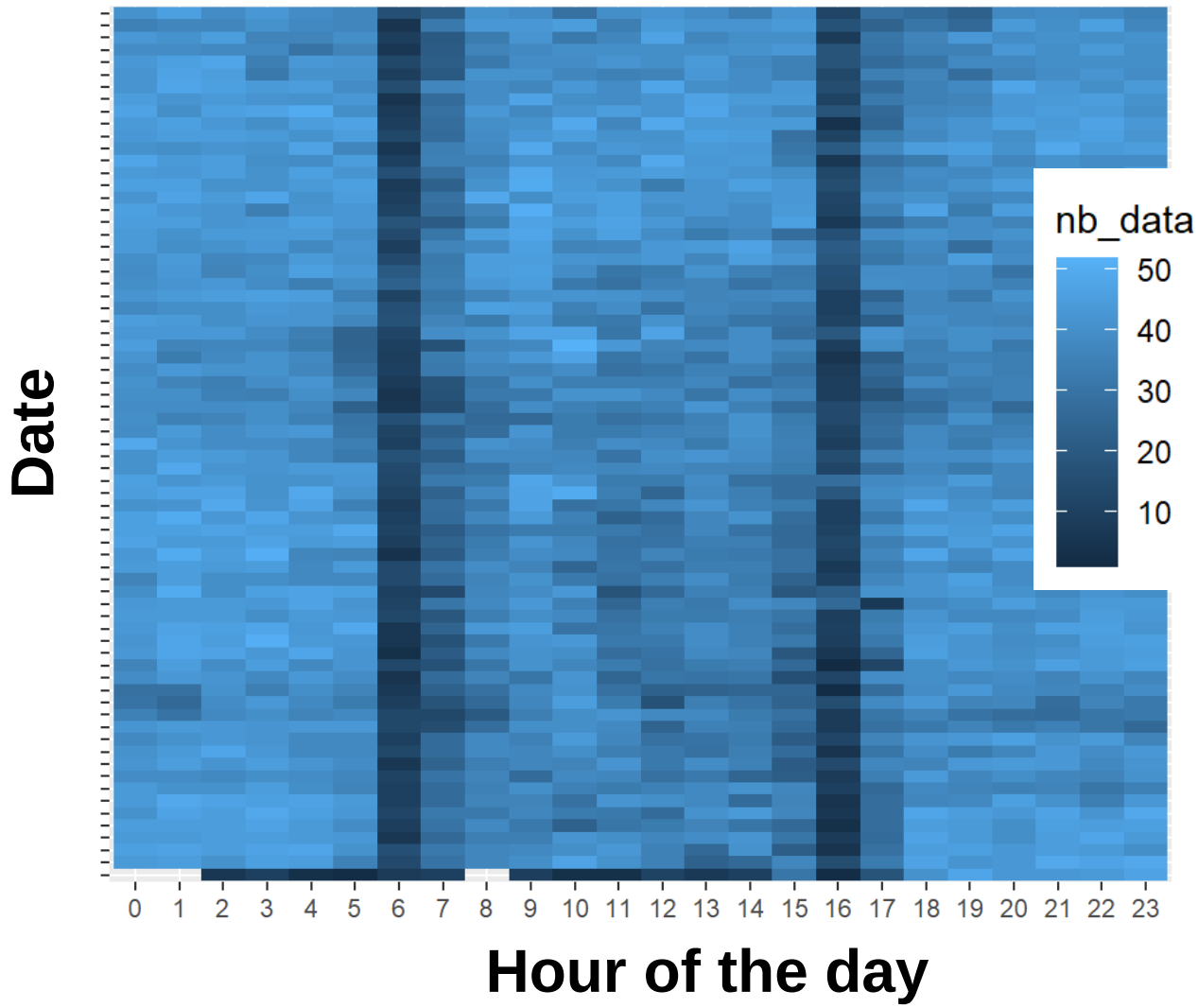
Low error of estimation (CV: 2,5-6%) ; Higher error for farm B due to grasslands system structure

Discussions

- GSM or IOT networks **coverage is not available everywhere**
- **Algorithm A :**
  - Needs a difference of positions density between barn and paddocks
  - **Needs GNSS data in the barn:**
    - not all herds are systematically housed in a barn in summer time
    - GNSS sensors work badly in some barns

    ➔ Not suitable in every systems

    ➔ Will work poorly if too much missing data due to poor connectivity
- **Algortihm B:**
  - Needs Farmer's input about paddocks map



Conclusion / perspective

- **Algorithms provide results compatible for traceability needs**
- Both algorithms provide similar results with low errors (CV < 6%)
- **But** :
  - **Algorithm A** needs high quality data, proper parameters to be adjusted for different farm systems, **but no paddocks' map**
    - ➢ Perspective for other applications with no knowledge of the area of interest
  - **Algorithm B** needs a map of the farm systems but is **very reproducible**
    - ➢ Has been deployed with GNSS on 22 commercial farms (Nicolas *et al.*, 2022)
    - ➢ Could be used for traceability solutions (API already implemented)

- Other outputs from GNSS sensors and algorithms can be provided (weekly positions visualisations, grazing calendar) see **Nicolas et al. (2022)**

Thank you for your attention

Horizon 2020
European Union Funding
for Research & Innovation

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References :

Hahsler, M., Piekenbrock, M. and Doran, D. (2019) *Dbscan: Fast density-based clustering with R.* Journal of Statistical Software 91, 1–30.

Lebreton A., Allain C., Charpentier C., D'Introno M., Fischer A., Lonis W., Nicolas E., Philibert A. (2022). *Are GPS sensors and density-based classification suitable to ensure the traceability of dairy cows on pastures? Part I: Development and validation on experimental farms.* In: Proc. ECPLF 2022, Vienna, 2022.

Nicolas, E., D'introno, M., Fischer, A., Lebreton, A., Philibert, A., and Allain C. (2022). *Are GPS sensors and density-based classification suitable to ensure the traceability of dairy cows on pastures? Part II: on-farm deployment*. In: Proc. ECPLF 2022, Vienna, 2022.

Results : Grazing time estimation

At the daily scale :

	Daily average TOut estimated by algorithm A	Daily average TOut estimated by algorithm B
Farm A (N=37 d)	RMSE = 17 min/d (CV = 2.5%)	RMSE = 19 min/d (CV = 2.8%)
Farm B 2019 (N=34 d)	RMSE = 40 min/d (CV= 3.5%)	RMSE = 39 min/d (CV = 3.4%)
Farm B 2020 (N=48 d)	RMSE = 50 min/d (CV = 6.0%)	RMSE = 46 min/d (CV = 5.5%)

At the period scale :

	Average Reference TOut	Average TOut estimated by algorithm A	Average TOut estimated by algorithm B
Farm A	676 ± 221 min/d	675 ± 217 min/d	665 ± 220 min/d
Farm B 2019	1132 ± 31 min/d	1156 ± 58 min/d	1153 ± 62 min/d
Farm B 2020	835 ± 377 min /d	829 ± 349 min/d	825 ± 352 min/d

Estimation error is below 1 hour (CV: 2,5-6%) at the daily scale and estimation errors balance out over the time at the period scale.

M&M : Algorithm B

Inputs

Many Corrections to apply

Outputs

TOut

Source of errors

Locations outside any polygons

GNSS inaccuracy due to the barn effect

Kinetic corrections of the labels

PPBPP -> PPPPP

Spatial corrections :

NA -> the closest polygon