



# From Raw Sniffer Data to Phenotypes

The pipeline in the Netherlands

29-04-2026 | Coralia Manzanilla Pech, Anouk van Breukelen

# The sniffers

**WD-WUR v1.0 and v2.0, manufactured by Carltech BV**

- NDIR sensors (Novasis Novagas)
- Pump of 1 L/min
- Inside is heated
- Samples every 5 seconds
- CH<sub>4</sub> 0 - 2,000 ppm
- CO<sub>2</sub> 0 - 10,000 ppm

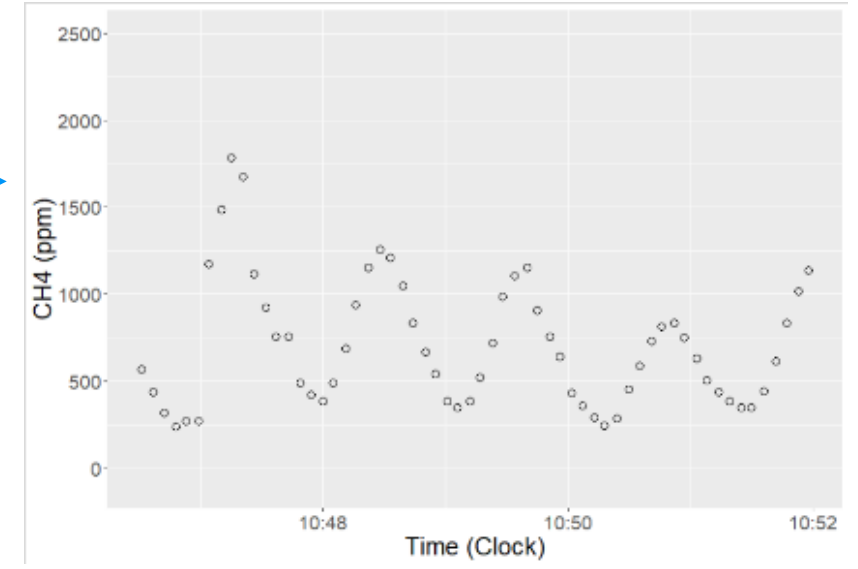
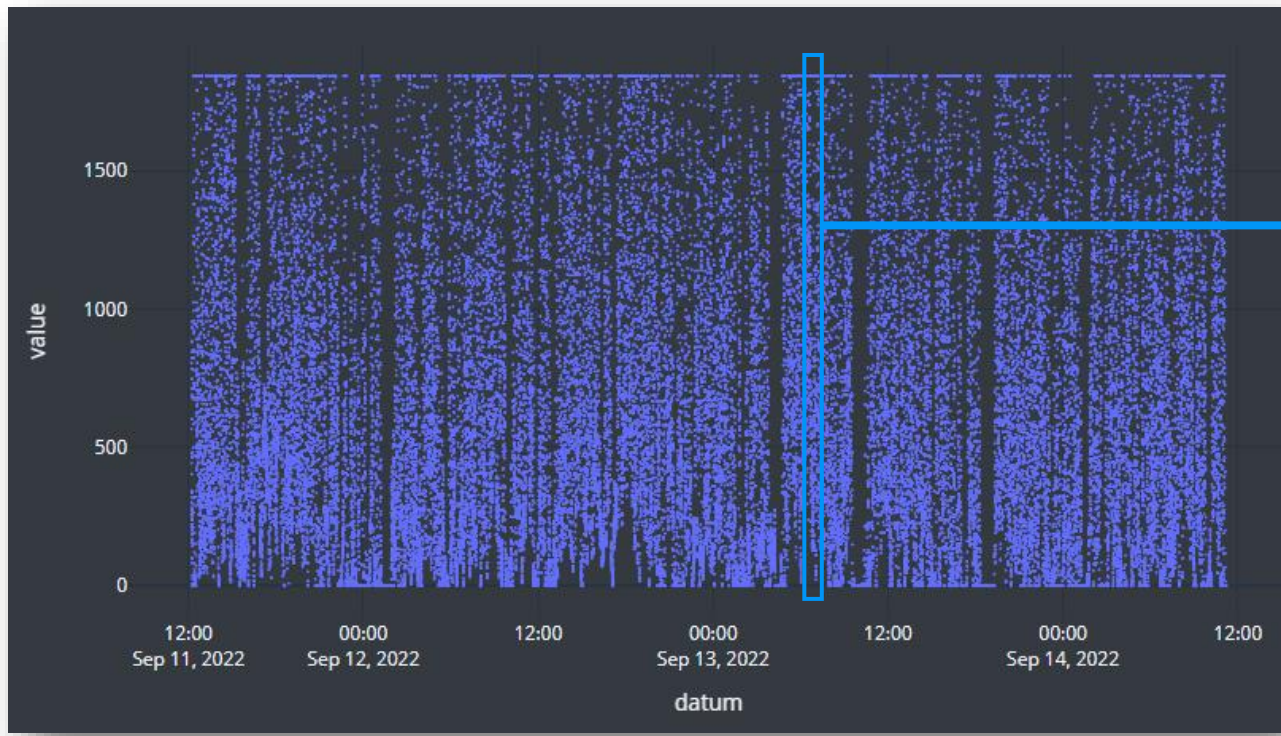


# Data processing

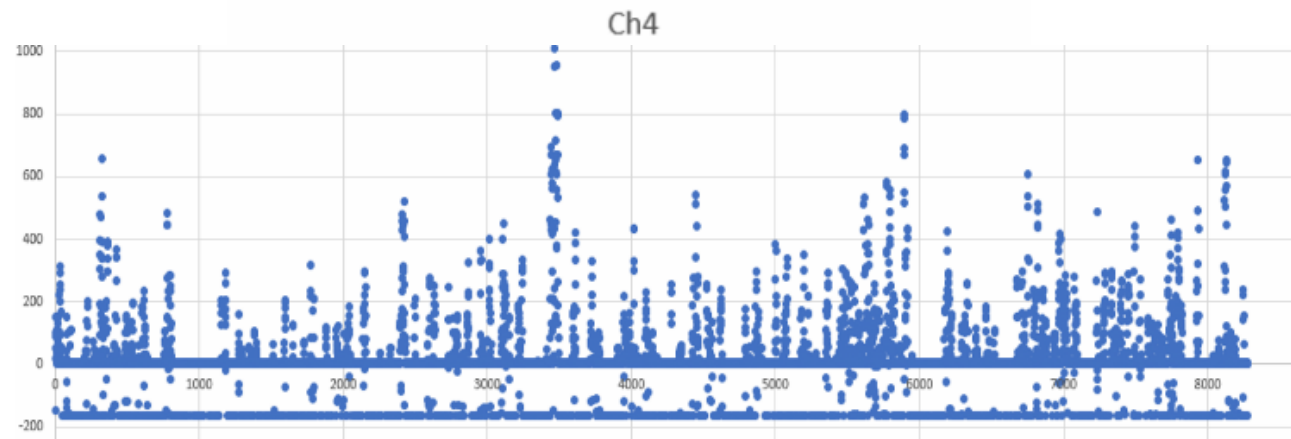
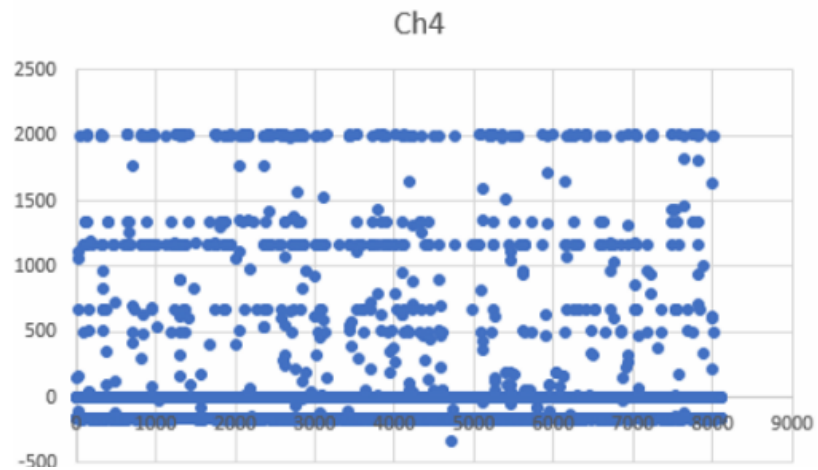
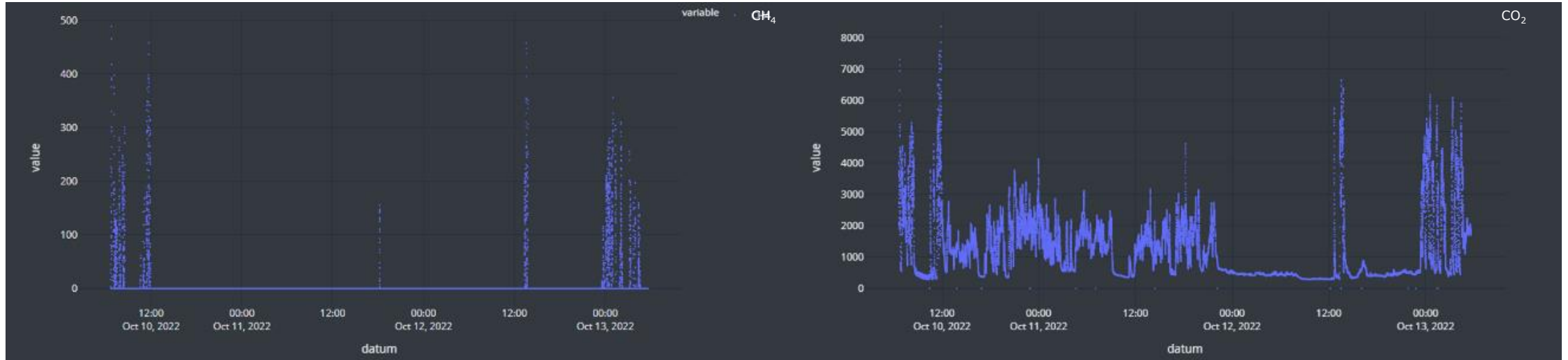
1. Downloading and automatic filtering of data
2. Matching CH<sub>4</sub> records to cow ID
3. Trait definition



# Example of good data



# Examples of data issues

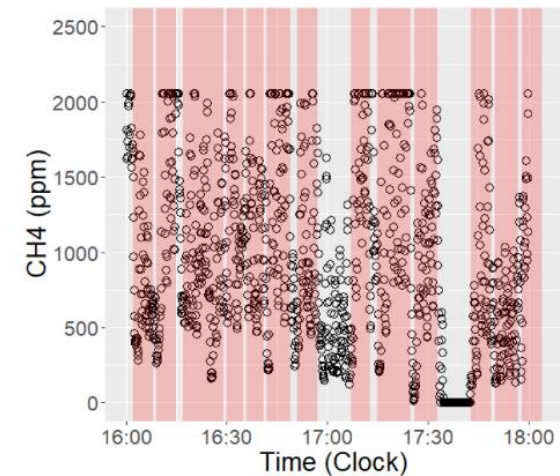
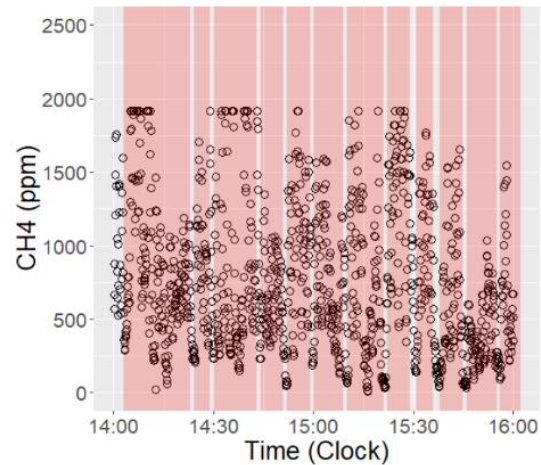
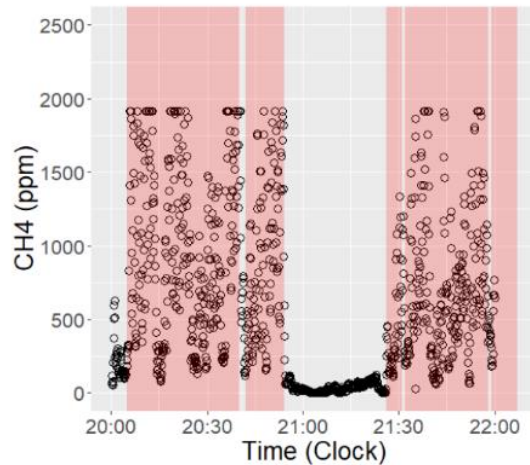


# Automatic data filtering

- During downloading data from Azure to local csv files with Python script
- Filtered within subset of farm, date and hour:
  - IQR > 200 ppm
  - Mean > 30 ppm
  - Less than 30% of data should be within 10 ppm of the first two modes
  - No measurements > 2,500 ppm (outside of detection range sensor)
- Thereafter, outliers are discarded:
  - < 0.001<sup>st</sup> quantile and > 0.999<sup>th</sup> quantile

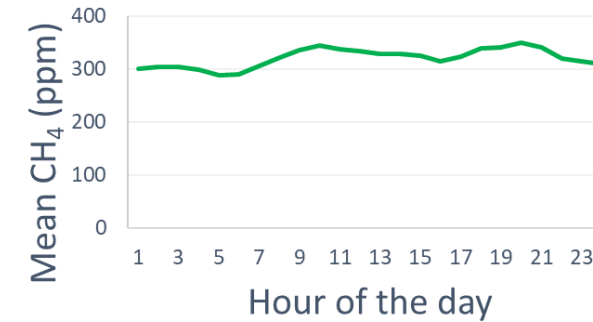
# Automatic matching to cow ID

- During downloading data from Azure to local csv files with *Python* script
- With IDs recorded by the milking robot
  - Matched based on timestamp (both devices synchronize to internet time)
  - Plotted and randomized visual checks on correct alignment



# Trait definition

- For CRV breeding program:
  - Average concentration (ppm) per week
- First average per visit is calculated:
  - Subtract background concentrations: 0.001 lowest quantile per farm per day
  - Discard records in the first 60 seconds of milking and after 300 seconds of milking
  - Discard records which, after filtering, last less than 150 seconds
- Then weekly means are computed:
  - Averaged after a diurnal correction on the visit means
  - 5 visits per week



# Overview of the Process



Sniffers (Carltech BV):

- WD-WUR v1.0 + Arduino (KE)
- WD-WUR v2.0 (PPS CSCB)

Connect sniffer to database with  
MethaanWatcher azurewebsite

Twice a week visually check if  
the sniffers work correctly with  
wlrsniffer azurewebsite  
(wlrsniffer.azurewebsites.net)

Microsoft Azure database:

euwstkemethanadatap -> container newdata  
(csv file per farm per day with CH<sub>4</sub>, CO<sub>2</sub>, and  
time of day)

Milkingrobot data from CRV (cow ID and date and time of  
milking) and cow information (Parity, Breed, calving date)

Python script to download the data to a local computer or  
HPC, filter out bad data, and connect to cow ID

Python script to prepare data for genetic  
evaluation by adding cow information

# Trait definition

## For research

|                          |    |   | Rg with CH4ppm              |
|--------------------------|----|---|-----------------------------|
| METHANE<br>CONCENTRATION | 1. | <b>conc</b> Average <i>methane concentration</i> per visit (ppm)            | <b>sumpeaks</b> 0.84 (0.02) |
|                          | 2. | <b>#peaks</b> <i>Number of methane peaks</i> per minute                     | <b>#peaks</b> 0.48 (0.06)   |
|                          | 3. | <b>Sumpeaks</b> Sum of 2 maximum values within each peak                    | <b>Madsen</b> 0.74 (0.13)   |
|                          | 4. | <b>ratio</b> between <i>methane</i> and <i>carbon dioxide</i> concentration | <b>Chagunda</b> 0.76 (0.08) |
| METHANE<br>PRODUCTION    | 5. | <b>Madsen</b> Based on Madsen equation                                      | <b>Kjeldsen</b> 0.91 (0.11) |
|                          | 6. | <b>Chagunda</b> Based on Chagunda equation                                  | <b>Tier2</b> -0.05 (0.16)   |
|                          | 7. | <b>Kjeldsen</b> Based on Kjeldsen equation                                  | <b>ratio</b> 0.86 (0.03)    |
|                          | 8. | <b>Tier2</b> Based on Tier2 (IPCC) equation                                 | <b>CO2</b> 0.84 (0.03)      |

# Work in progress

## Continuous updating of pipelines and trait definition

Possibly of interest to implement, for example:

- Check on full coverage of visit
- Defining a minimum number of peaks in a visit
- Using only repeatable data
  - Repeatability e.g.  $> 0.1$  or  $0.3$



# Thank you for your attention!

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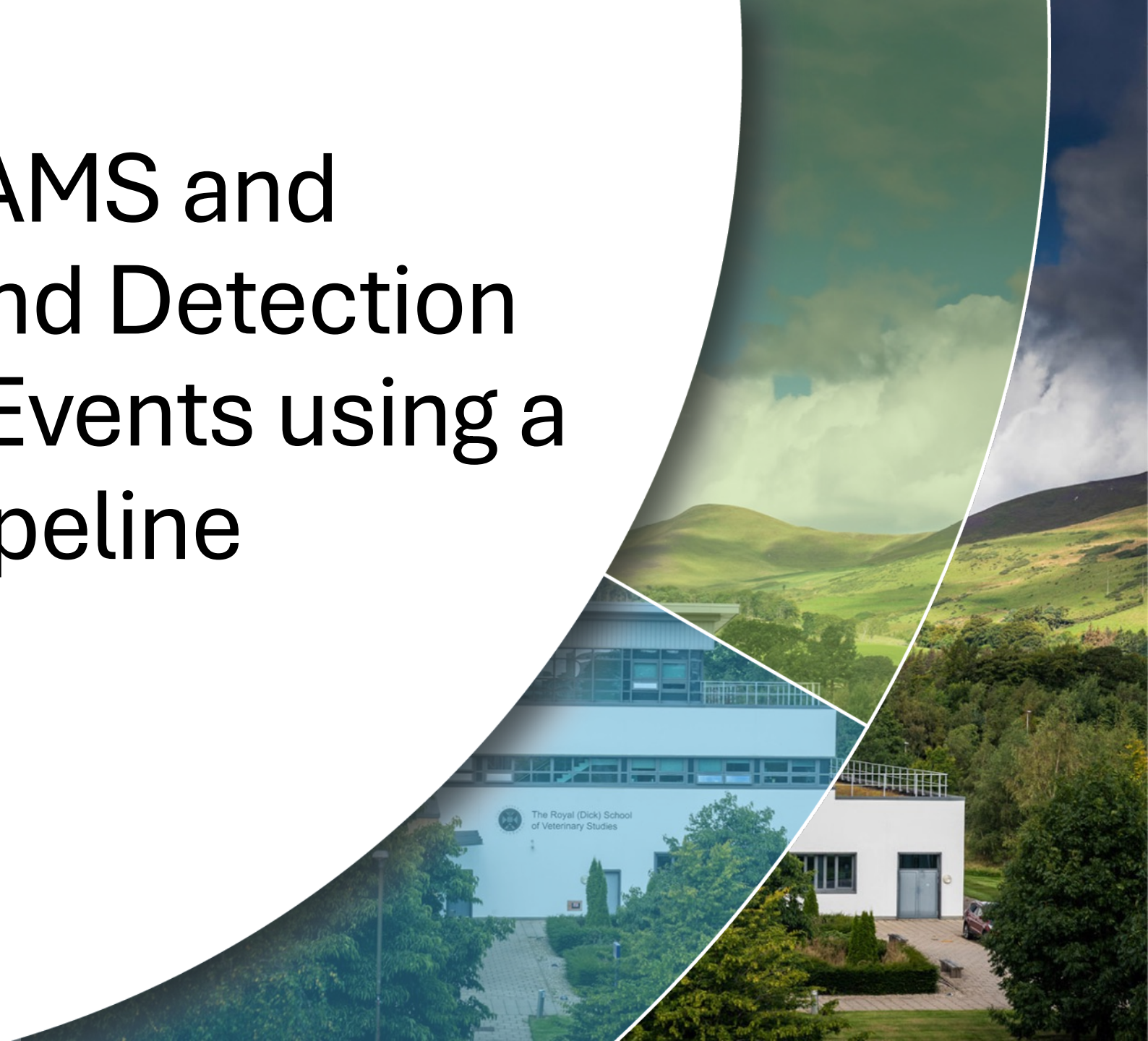


# Alignment of AMS and Sniffer Data and Detection of Eructation Events using a Java-based pipeline

Oscar González Recio

GMG webinar

29 April 2026





01

Sniffer setup

02

Data processing

03

Output

# Setup of sniffers

Current set-up

Measurements every second

Manual data download from AMS



# Timestamps in the data



Sincronize times



# Lag time in the sniffer

- Time the gas takes to travel from feed-bin to the sniffer sensor
- How it is measured:
  - Release some known gas at known concentration in the feedbin, count the seconds until the sniffer register the gas ppm

# Raw Data

ORFOTRIZUCI\_TOT\_Loggy\_74

| Date and time       | CH4   | CO2   |
|---------------------|-------|-------|
| 03/12/2021 11:50:00 | 0,018 | 0,095 |
| 03/12/2021 11:50:01 | 0,018 | 0,095 |
| 03/12/2021 11:50:02 | 0,018 | 0,093 |
| 03/12/2021 11:50:03 | 0,018 | 0,094 |
| 03/12/2021 11:50:04 | 0,018 | 0,093 |
| 03/12/2021 11:50:05 | 0,018 | 0,095 |
| 03/12/2021 11:50:06 | 0,018 | 0,093 |
| 03/12/2021 11:50:07 | 0,018 | 0,095 |
| 03/12/2021 11:50:08 | 0,018 | 0,095 |
| 03/12/2021 11:50:09 | 0,018 | 0,095 |
| 03/12/2021 11:50:10 | 0,018 | 0,095 |
| 03/12/2021 11:50:11 | 0,018 | 0,095 |
| 03/12/2021 11:50:12 | 0,019 | 0,095 |
| 03/12/2021 11:50:13 | 0,019 | 0,095 |
| 03/12/2021 11:50:14 | 0,019 | 0,094 |
| 03/12/2021 11:50:15 | 0,019 | 0,093 |
| 03/12/2021 11:50:16 | 0,019 | 0,094 |
| 03/12/2021 11:50:17 | 0,02  | 0,095 |
| 03/12/2021 11:50:18 | 0,02  | 0,095 |
| 03/12/2021 11:50:19 | 0,02  | 0,095 |
| 03/12/2021 11:50:20 | 0,02  | 0,095 |
| 03/12/2021 11:50:21 | 0,02  | 0,095 |
| 03/12/2021 11:50:22 | 0,02  | 0,097 |
| 03/12/2021 11:50:23 | 0,02  | 0,096 |
| 03/12/2021 11:50:24 | 0,021 | 0,095 |
| 03/12/2021 11:50:25 | 0,021 | 0,095 |

| Numero vaca | Adres | Fecha/Hora de visita | tiempo en cubiculo | Produccion de leche | Tiempo  | Descripcion | CIB        |
|-------------|-------|----------------------|--------------------|---------------------|---------|-------------|------------|
| 161         | 102   | 22/11/2021 0:02:00   | 4:26               | 18.8                | 6:04    | Correcto    | ES03111219 |
| 148         | 102   | 22/11/2021 0:15:00   | 10:08              | 10.9                | 11:39   | Correcto    | ES02111264 |
| 193         | 102   | 22/11/2021 0:23:00   | 6:01               | 15.8                | 7:38    | Correcto    | ES09111196 |
| 110         | 102   | 22/11/2021 0:28:00   | 3:45               | 14.4                | 5:04    | Correcto    | ES04111244 |
| 136         | 102   | 22/11/2021 0:35:00   | 5:37               | 15.1                | 7:11    | Correcto    | ES09111219 |
| 158         | 102   | 22/11/2021 0:43:00   | 5:42               | 15.9                | 7:29    | Correcto    | ES03111244 |
| 257         | 102   | 22/11/2021 0:48:00   | 3:41               | 11.3                | 5:20    | Correcto    | ES09111264 |
| 178         | 102   | 22/11/2021 0:54:00   | 3:44               | 14.6                | 5:24    | Correcto    | ES06111244 |
| 142         | 102   | 22/11/2021 1:01:00   | 5:01               |                     | 15 6:35 | Correcto    | ES03111219 |



| CIB     | cow | date                         | kgm  | time  | meanCH4 | meanCO2 | meanRatioCH4_CO2 | peaks | Sum_of_PeaksCH4    | Sum_of_PeaksCO2    | Sum_of_PeaksRatio   | AUC_CH4 | AUC_Ratio | Mean_of_PeaksCH4   | Mean_of_PeaksRatio   | validity |
|---------|-----|------------------------------|------|-------|---------|---------|------------------|-------|--------------------|--------------------|---------------------|---------|-----------|--------------------|----------------------|----------|
| ES04111 | 230 | Mon Nov 22 19:48:33 CET 2021 | 17.1 | 398.0 | 388.52  | 5224.3  | 0.08             | 6     | 1482.8071148459383 | 36504.70058512293  | 0.20990055440186733 | 9978.99 | 1.37      | 247.1345191409897  | 0.03498342573364455  | 0        |
| ES07111 | 121 | Mon Nov 22 19:59:33 CET 2021 | 0.7  | 218.0 | 143.03  | 4209.27 | 0.07             | 3     | 392.1966794380587  | 13818.945593869732 | 0.14540231828572295 | 4879.82 | 1.9       | 130.7322264793529  | 0.048467439428574316 | 11       |
| ES02111 | 186 | Mon Nov 22 20:06:54 CET 2021 | 15.7 | 257.0 | 77.83   | 3027.98 | 0.07             | 3     | 227.29635854341737 | 11562.271820728292 | 0.1257196611920071  | 2248.25 | 1.19      | 75.76545284780579  | 0.04190655373066903  | 10       |
| ES04111 | 275 | Mon Nov 22 20:13:10 CET 2021 | 12.0 | 301.0 | 159.91  | 3662.45 | 0.11             | 5     | 485.00529320666624 | 18271.33913505767  | 0.5307052327703151  | 3715.61 | 4.02      | 97.00105864133324  | 0.10614104655406302  | 10       |
| ES01111 | 368 | Mon Nov 22 20:19:49 CET 2021 | 10.8 | 321.0 | 83.1    | 5698.58 | 0.09             | 5     | 943.7062980030722  | 35488.7873015873   | 0.11710308352325392 | 6333.54 | 0.8       | 188.74125960061446 | 0.023420616704650784 | 0        |
| ES06111 | 160 | Mon Nov 22 20:25:13 CET 2021 | 0.6  | 411.0 | 73.6    | 4022.3  | 0.09             | 6     | 996.6991341991343  | 33887.80194805195  | 0.20150781394808717 | 5467.46 | 1.23      | 166.1165226665224  | 0.033584635658014526 | 0        |
| ES05111 | 30  | Mon Nov 22 20:34:27 CET 2021 | 14.2 | 284.0 | 58.84   | 1541.71 | 0.13             | 1     | 39.7752808988764   | 1414.1573033707866 | 0.10767299876464806 | 1470.42 | 4.0       | 39.7752808988764   | 0.10767299876464806  | 10       |
| ES09111 | 259 | Mon Nov 22 20:40:59 CET 2021 | 9.6  | 312.0 | 125.06  | 3196.0  | 0.05             | 4     | 452.8353227232538  | 15736.551503094608 | 0.17945967803194526 | 4218.08 | 1.7       | 113.20883068081345 | 0.044864919507986316 | 1        |
| ES06111 | 168 | Mon Nov 22 20:48:18 CET 2021 | 20.6 | 353.0 | 182.54  | 3645.61 | 0.07             | 5     | 577.9823654606263  | 18021.85005574136  | 0.3152943286704917  | 4330.2  | 2.38      | 115.59647309212525 | 0.06305886573409833  | 10       |
| ES04111 | 123 | Mon Nov 22 20:56:29 CET 2021 | 14.0 | 342.0 | 84.08   | 1892.72 | 0.18             | 4     | 329.7845117845118  | 9928.445993265992  | 0.4332130926953546  | 2649.12 | 3.33      | 82.44612794612794  | 0.10830327317383864  | 0        |
| ES08111 | 364 | Mon Nov 22 21:25:18 CET 2021 | 17.7 | 353.0 | 124.63  | 2983.51 | 0.12             | 3     | 416.18426501035196 | 11718.461490688323 | 0.16710207260913496 | 2575.07 | 1.12      | 138.728088336784   | 0.055700690869711654 | 10       |
| ES07111 | 253 | Mon Nov 22 21:33:45 CET 2021 | 16.4 | 386.0 | 143.62  | 3937.58 | 0.1              | 5     | 638.1588738059327  | 20841.785816728847 | 0.38961611552911024 | 6160.1  | 3.95      | 127.63177476118653 | 0.07792322310582205  | 10       |
| ES05111 | 179 | Mon Nov 22 21:42:08 CET 2021 | 12.1 | 603.0 | 187.48  | 2412.15 | 0.23             | 7     | 1207.601986249045  | 21018.304430863256 | 1.353011447947969   | 6426.87 | 9.86      | 172.51456946414928 | 0.1932873497068527   | 0        |
| ES08111 | 153 | Mon Nov 22 21:54:12 CET 2021 | 12.3 | 239.0 | 93.29   | 3023.13 | 0.11             | 2     | 211.11226611226613 | 9635.074844074843  | 0.06837873515197078 | 3180.75 | 1.03      | 105.55613305613306 | 0.03418936757598539  | 0        |
| ES08111 | 233 | Mon Nov 22 22:00:32 CET 2021 | 12.4 | 459.0 | 65.35   | 1708.46 | 0.12             | 5     | 349.9339738923324  | 11015.28748938095  | 0.42803751793536104 | 3556.86 | 4.5       | 69.98679477846648  | 0.08560750358707221  | 0        |
| ES01111 | 243 | Mon Nov 22 22:10:03 CET 2021 | 21.5 | 308.0 | 232.21  | 5241.77 | 0.06             | 4     | 866.969696969697   | 24427.121212121212 | 0.2342820593185971  | 8578.83 | 2.08      | 216.74242424242425 | 0.05857051482964928  | 10       |
| ES01111 | 135 | Mon Nov 22 22:16:43 CET 2021 | 11.1 | 268.0 | 220.28  | 5748.11 | 0.06             | 4     | 569.2437160540609  | 25125.016420361248 | 0.17554566167125346 | 6377.46 | 2.02      | 142.31092901351522 | 0.043886415417813365 | 10       |
| ES05111 | 180 | Mon Nov 22 22:22:57 CET 2021 | 10.8 | 674.0 | 140.17  | 6116.57 | 0.04             | 11    | 1423.3539729111376 | 72146.39184785487  | 0.3804216924355346  | 6294.48 | 1.72      | 129.39581571919433 | 0.03458379022414223  | 10       |
| ES09111 | 189 | Mon Nov 22 22:36:04 CET 2021 | 13.2 | 307.0 | 128.16  | 4759.58 | 0.06             | 4     | 376.9674621709726  | 22420.723981900454 | 0.10450932553531182 | 3536.29 | 1.02      | 94.24186554274316  | 0.026127331383827956 | 10       |
| ES03111 | 158 | Mon Nov 22 22:43:15 CET 2021 | 18.3 | 416.0 | 103.82  | 2997.8  | 0.09             | 4     | 434.45247897642264 | 15196.337130475158 | 0.2580819528163808  | 4414.04 | 2.94      | 108.61311974410566 | 0.0645204882040952   | 10       |
| ES09111 | 246 | Mon Nov 22 22:52:00 CET 2021 | 16.4 | 671.0 | 134.73  | 3133.5  | 0.11             | 6     | 878.4542245194419  | 24473.33101922232  | 0.5466706894738621  | 4159.94 | 2.15      | 146.40903741990698 | 0.09111178157897702  | 0        |

OUTPUT

# Process data files

Executable java .jar file with 3 input parameters:

```
Java -jar Analyzer.java <traffic file> <Sniffer file> <lag time>
```

# Process data files

```
38  /* Check we have 3 arguments */
39  if (args.length != 3) {
40      System.out.println("Usage: java -jar ExtractSnifferDataLelyA4.jar <AMS file> <Sniffer file> <clock_lag> ");
41      System.exit(0);
42  }
43  clocks_lag=Integer.parseInt(args[2])*1000;
```

[...]

```
246  while (ch4_iter.hasNext() & dateInSniffer_iter.hasNext()){
247      double ch4j=ch4_iter.next();double co2j=co2_iter.next();Date
      dateSnifferj=dateInSniffer_iter.next();
248
249      if (dateSnifferj.getTime()-dateAMS[i].getTime() >= clocks_lag &
      dateSnifferj.getTime()-dateAMSfinal[i].getTime() < clocks_lag) { //If the sniffer
      clock is between the entrance and exit time of the cow, add the methane ppm record
      tempdate.add(dateSnifferj);tempch4.add(ch4j);tempco2.add(co2j);
250  }else if (dateSnifferj.getTime()-dateAMSfinal[i].getTime() == clocks_lag) { //if the
251  Sniffer clocks matches AMS clock
      ch4Data.add(new cowCH4Data(cow[i],milk[i],tempdate,tempch4,tempco2,cib[i]));
252      break;
253  }else if (dateSnifferj.getTime()-dateAMSfinal[i].getTime() > clocks_lag) { //if the
254  Sniffer clock is larger than AMS clock, go to next record
      break;
255  }
256  }
257  }
```

→ Create object for emission records during milking

[...]

Read files

Cow transit in AMS and Sniffer

Read through files and compare  
timestamp in both files

(take lag into account)

When equal:

Assign sniffer data during  
milking to cow ID from AMS data  
(max of 5 minutes)



# METHANE PHENOTYPING

- Phenotype definition (weekly averages post processed with *in-house* Rscripts)

1. Mean CH<sub>4</sub> (by second)
2. Sum of peaks CH<sub>4</sub> (by second)
3. Sum of max peaks CH<sub>4</sub>
4. Area under the curve (AUC CH<sub>4</sub>)
5. Ratio of (mean) CH<sub>4</sub>/CO<sub>2</sub>

6. CH<sub>4</sub> grams per day (Madsen et al., 2010)

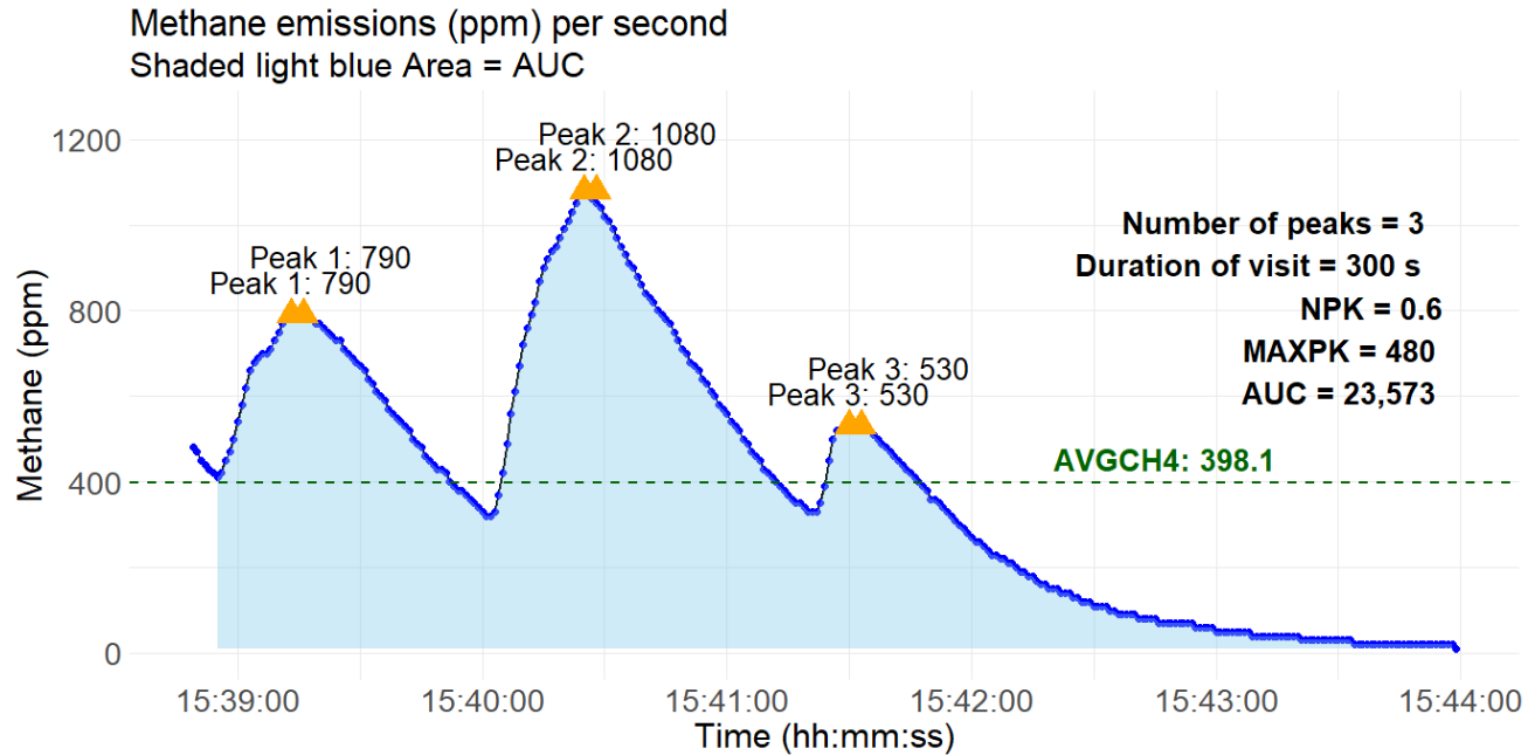
$$\text{Prod CH}_4\left(\frac{g}{d}\right) = 0.714 * \mathbf{ratio(ppm)} * 180 * 24 * 0.001 * (5.6 * \mathbf{kg\ body\ mass}^{0.75}) \\ + 22 * \mathbf{ECM} + 1.6 * 10^{-5} * \mathbf{days\ in\ pregnancy}$$

Postprocessing

7. CH<sub>4</sub> grams per day (in-house\*, based on observed CO<sub>2</sub> and CH<sub>4</sub>/CO<sub>2</sub> ratio, *to be published*)

Large genetic correlation between phenotypes

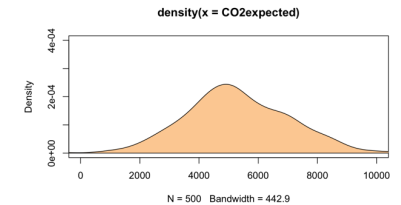
# Phenotype definition



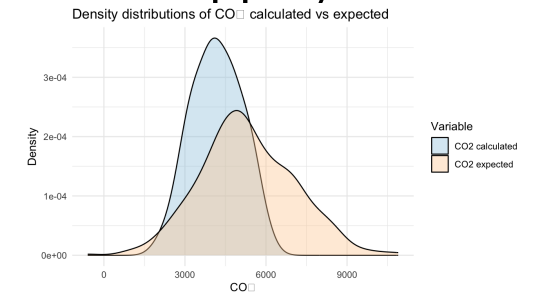
# Phenotype definition

- Convert ppm to g/d
- Uses CH<sub>4</sub>/CO<sub>2</sub> ratio
- For each Comparison Group calculate expected CO<sub>2</sub> emissions per cow

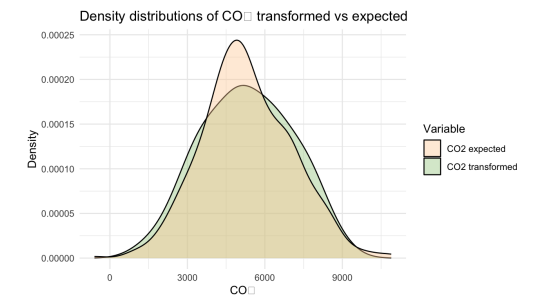
(Pedersen et al, 2008)



- Estimate CO<sub>2</sub> from sniffer sample (depending on sniffer flow and cow breath CO<sub>2</sub> ppm)



- Transform distribution from observed samples to expected



# Phenotype definition

- Convert methane concentration to methane production based on CH<sub>4</sub>/CO<sub>2</sub> ratio and transformed CO<sub>2</sub> production

$$CH_{4\ ij} \left( \frac{L}{d} \right) = CO_{2\ ij} \left( \frac{L}{d} \right) * \frac{CH_{4\ ij} \text{ (ppm)}}{CO_{2\ ij} \text{ (ppm)}}$$

- Use density of methane (0.714 g/L at 0°C – 0.657 g/L at 25°C) to convert to g/d

# OUTPUT

| cow | date                         | kgm  | time  | meanCH4 | meanCO2 | meanRatioCH4_CO2 | peaks | Sum_of_PeaksCH4    | Sum_of_PeaksCO2    | Sum_of_PeaksRatio   | AUC_CH4 | AUC_Ratio | Mean_of_PeaksCH4   | Mean_of_PeaksRatio   | validity |
|-----|------------------------------|------|-------|---------|---------|------------------|-------|--------------------|--------------------|---------------------|---------|-----------|--------------------|----------------------|----------|
| 230 | Mon Nov 22 19:48:33 CET 2021 | 17.1 | 398.0 | 388.52  | 5224.3  | 0.08             | 6     | 1482.8071148459383 | 36504.70058512293  | 0.20990055440186733 | 9978.99 | 1.37      | 247.1345191409897  | 0.03498342573364455  | 0        |
| 121 | Mon Nov 22 19:59:33 CET 2021 | 0.7  | 218.0 | 143.03  | 4209.27 | 0.07             | 3     | 392.1966794380587  | 13818.945593869732 | 0.14540231828572295 | 4879.82 | 1.9       | 130.7322264793529  | 0.048467439428574316 | 11       |
| 186 | Mon Nov 22 20:06:54 CET 2021 | 15.7 | 257.0 | 77.83   | 3027.98 | 0.07             | 3     | 227.29635854341737 | 11562.271820728292 | 0.1257196611920071  | 2248.25 | 1.19      | 75.76545284780579  | 0.04190655373066903  | 10       |
| 275 | Mon Nov 22 20:13:10 CET 2021 | 12.0 | 301.0 | 159.91  | 3662.45 | 0.11             | 5     | 485.00529320666624 | 18271.33913505767  | 0.5307052327703151  | 3715.61 | 4.02      | 97.00105864133324  | 0.10614104655406302  | 10       |
| 368 | Mon Nov 22 20:19:49 CET 2021 | 10.4 | 322.0 | 383.1   | 5698.58 | 0.09             | 5     | 943.7062980030722  | 35488.7873015873   | 0.11710308352325392 | 6333.54 | 0.8       | 188.74125960061446 | 0.023420616704650784 | 0        |
| 160 | Mon Nov 22 20:25:13 CET 2021 | 0.0  | 418.0 | 173.68  | 4022.3  | 0.09             | 6     | 996.6991341991343  | 33887.80194805195  | 0.20150781394808717 | 5467.46 | 1.23      | 166.1165223665224  | 0.033584635658014526 | 0        |
| 30  | Mon Nov 22 20:34:27 CET 2021 | 14.2 | 284.0 | 58.84   | 1541.71 | 0.13             | 1     | 39.7752808988764   | 1414.1573033707866 | 0.10767299876464806 | 1470.42 | 4.0       | 39.7752808988764   | 0.10767299876464806  | 10       |
| 259 | Mon Nov 22 20:40:59 CET 2021 | 9.6  | 312.0 | 125.06  | 3196.0  | 0.05             | 4     | 452.8353227232538  | 15736.551503094608 | 0.17945967803194526 | 4218.08 | 1.7       | 113.20883068081345 | 0.044864919507986316 | 1        |
| 168 | Mon Nov 22 20:48:18 CET 2021 | 20.6 | 353.0 | 182.54  | 3645.61 | 0.07             | 5     | 577.9823654606263  | 18021.85005574136  | 0.3152943286704917  | 4330.2  | 2.38      | 115.59647309212525 | 0.06305886573409833  | 10       |
| 123 | Mon Nov 22 20:56:29 CET 2021 | 14.0 | 342.0 | 84.08   | 1892.72 | 0.18             | 4     | 329.7845117845118  | 9928.445993265992  | 0.4332130926953546  | 2649.12 | 3.33      | 82.44612794612794  | 0.10830327317383864  | 0        |
| 364 | Mon Nov 22 21:25:18 CET 2021 | 17.7 | 353.0 | 124.63  | 2983.51 | 0.12             | 3     | 416.18426501035196 | 11718.46149068323  | 0.16710207260913496 | 2575.07 | 1.12      | 138.728088336784   | 0.055700690869711654 | 10       |
| 253 | Mon Nov 22 21:33:45 CET 2021 | 16.4 | 386.0 | 143.62  | 3937.58 | 0.1              | 5     | 638.1588738059327  | 20841.785816728847 | 0.38961611552911024 | 6160.1  | 3.95      | 127.63177476118653 | 0.07792322310582205  | 10       |
| 179 | Mon Nov 22 21:42:08 CET 2021 | 12.1 | 603.0 | 187.48  | 2412.15 | 0.23             | 7     | 1207.601986249045  | 21018.304430863256 | 1.353011447947969   | 6426.87 | 9.86      | 172.51456946414928 | 0.1932873497068527   | 0        |
| 153 | Mon Nov 22 21:54:12 CET 2021 | 12.3 | 239.0 | 93.29   | 3023.13 | 0.11             | 2     | 211.11226611226613 | 9635.074844074843  | 0.06837873515197078 | 3180.75 | 1.03      | 105.55613305613306 | 0.03418936757598539  | 0        |
| 233 | Mon Nov 22 22:00:32 CET 2021 | 12.4 | 459.0 | 65.35   | 1708.46 | 0.12             | 5     | 349.9339738923324  | 11015.28748938095  | 0.42803751793536104 | 3556.86 | 4.5       | 69.98679477846648  | 0.08560750358707221  | 0        |
| 243 | Mon Nov 22 22:10:03 CET 2021 | 21.5 | 308.0 | 232.21  | 5241.77 | 0.06             | 4     | 866.969696969697   | 24427.121212121212 | 0.2342820593185971  | 8578.83 | 2.08      | 216.74242424242425 | 0.05857051482964928  | 10       |
| 135 | Mon Nov 22 22:16:43 CET 2021 | 11.1 | 268.0 | 220.28  | 5748.11 | 0.06             | 4     | 569.2437160540609  | 25125.016420361248 | 0.17554566167125346 | 6377.46 | 2.02      | 142.31092901351522 | 0.043886415417813365 | 10       |
| 180 | Mon Nov 22 22:22:57 CET 2021 | 10.8 | 674.0 | 140.17  | 6116.57 | 0.04             | 11    | 1423.3539729111376 | 72146.39184785487  | 0.3804216924355346  | 6294.48 | 1.72      | 129.39581571919433 | 0.03458379022141223  | 10       |
| 189 | Mon Nov 22 22:36:04 CET 2021 | 13.2 | 307.0 | 128.16  | 4759.58 | 0.06             | 4     | 376.9674621709726  | 22420.723981900454 | 0.10450932553531182 | 3536.29 | 1.02      | 94.24186554274316  | 0.026127331383827956 | 10       |
| 158 | Mon Nov 22 22:43:15 CET 2021 | 18.3 | 416.0 | 103.82  | 2997.8  | 0.09             | 4     | 434.45247897642264 | 15196.337130475158 | 0.2580819528163808  | 4414.04 | 2.94      | 108.61311974410566 | 0.0645204882040952   | 10       |
| 246 | Mon Nov 22 22:52:00 CET 2021 | 16.4 | 671.0 | 134.73  | 3133.5  | 0.11             | 6     | 878.4542245194419  | 24473.33101922232  | 0.5466706894738621  | 4159.94 | 2.15      | 146.40903741990698 | 0.09111178157897702  | 0        |

# Filtering out

- Methane records

CO<sub>2</sub><2500.

> +/- 3SD in the comparison group

<5 or >35 records per week (remove all records in that week)

Remove weeks with <5 records, and animals with only 1 week of records

- CO<sub>2</sub> records

<2500

> +/- 3SD in the comparison group

- CH<sub>4</sub>/CO<sub>2</sub> records

ratio>0.3

> +/- 3SD in the comparison group

Average data per **week** (day), for consistency  
(more reliable heritability estimates)

# Raw Data

## OUTPUT

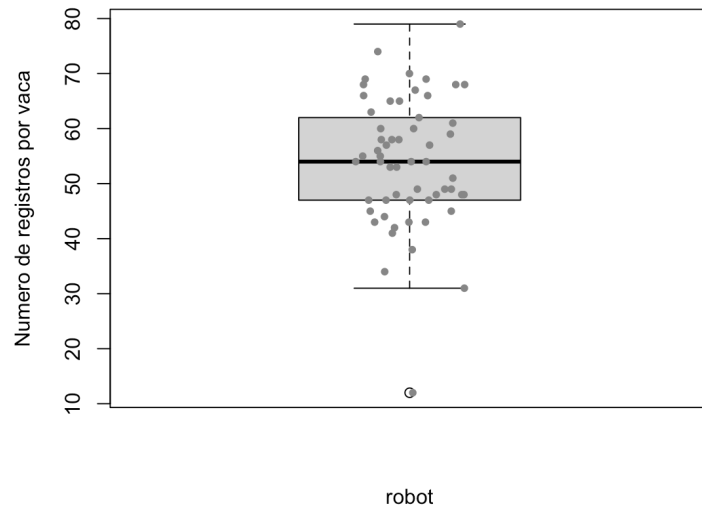


| CIB | cow | date | kgm                          | time | meanCH4 | meanCO2 | meanRatioCH4_CO2 | peaks | Sum of PeaksCH4 | Sum of PeaksCO2    | Sum of PeaksRatio  | AUC_CH4             | AUC_Ratio | Mean_of_PeaksCH4 | Mean_of_PeaksRatio | validity             | tes | numero | collar | nupadre | numpar | DEL | metodo | leche | grasa | proteina | lactosa | fcontrol | fpar | cib                | ultimaFCub         | DespuesUltParto | PesoVivo |                    |         |
|-----|-----|------|------------------------------|------|---------|---------|------------------|-------|-----------------|--------------------|--------------------|---------------------|-----------|------------------|--------------------|----------------------|-----|--------|--------|---------|--------|-----|--------|-------|-------|----------|---------|----------|------|--------------------|--------------------|-----------------|----------|--------------------|---------|
| ES  |     | 230  | Mon Nov 22 19:48:33 CET 2021 | 17.1 | 398.0   | 388.52  | 5224.3           | 0.08  | 6               | 1482.8071148459393 | 36504.70058512293  | 0.20990055440186733 | 9978.99   | 1.37             | 247.1345191409897  | 0.03498342573364455  | 0   | 12     | ESPH1  | 4663    | ESPM   |     | 1      | 318   | n1    | 49,90    | 3,62    | 3,26     | 5,01 | 07/12/2021 0:00:00 | 23/01/2021 0:00:00 | ES              |          | 10/09/2021 0:00:00 | 690,925 |
| ES  |     | 121  | Mon Nov 22 19:59:33 CET 2021 | 0.7  | 218.0   | 143.03  | 4209.27          | 0.07  | 3               | 392.1966794380567  | 13818.945593869732 | 0.14540231828572295 | 4679.82   | 1.9              | 130.7322264793529  | 0.048467439428574316 | 11  | 12     | ESPH1  | 9480    | 840M3  |     | 1      | 170   | n1    | 49,70    | 2,19    | 3,21     | 5,01 | 07/12/2021 0:00:00 | 20/06/2021 0:00:00 | ES              |          | 24/08/2021 0:00:00 | 657,413 |
| ES  |     | 275  | Mon Nov 22 20:13:10 CET 2021 | 12.0 | 301.0   | 159.91  | 3662.45          | 0.11  | 5               | 485.00529320666624 | 18271.33913505767  | 0.5307052327703151  | 3715.61   | 4.02             | 97.00105864133324  | 0.10614104655406302  | 10  | 12     | ESPH1  | 9478    | 840M3  |     | 1      | 98    | n1    | 40,50    | 3,23    | 3,16     | 5,21 | 07/12/2021 0:00:00 | 31/08/2021 0:00:00 | ES              |          | 04/11/2021 0:00:00 | 578,523 |
| ES  |     | 368  | Mon Nov 22 20:18:49 CET 2021 | 10.4 | 322.0   | 383.1   | 5698.58          | 0.09  | 5               | 943.7062980030722  | 35488.7873015873   | 0.11710308325235392 | 6333.54   | 0.8              | 188.74125960061446 | 0.023420616704650784 | 0   | 12     | ESPH1  | 9479    | 840M3  |     | 1      | 274   | n1    | 35,50    | 3,32    | 3,47     | 4,85 | 07/12/2021 0:00:00 | 08/03/2021 0:00:00 | ES              |          | 21/05/2021 0:00:00 | 647,666 |
| ES  |     | 160  | Mon Nov 22 20:25:13 CET 2021 | 0.0  | 418.0   | 173.68  | 4022.3           | 0.09  | 6               | 996.6991341991343  | 33887.80194805195  | 0.20150781394808717 | 5467.46   | 1.23             | 166.1165223665224  | 0.033584635658014526 | 0   | 12     | ESPH1  | 4692    | CANM   |     | 1      | 482   | n1    | 19,20    | 4,44    | 4,47     | 4,73 | 07/12/2021 0:00:00 | 12/08/2020 0:00:00 | ES              |          | 24/06/2021 0:00:00 | 590,568 |
| ES  |     | 30   | Mon Nov 22 20:34:27 CET 2021 | 14.2 | 284.0   | 58.84   | 1541.71          | 0.13  | 1               | 39.7752808988764   | 1414.1573033707866 | 0.1076729876464806  | 1470.42   | 4.0              | 39.7752808988764   | 0.1076729876464806   | 10  | 12     | ESPH1  | 4723    | ESPM5  |     | 1      | 339   | n1    | 28,70    | 4,53    | 3,97     | 4,66 | 07/12/2021 0:00:00 | 02/01/2021 0:00:00 | ES              |          | 21/05/2021 0:00:00 | 615,612 |
| ES  |     | 168  | Mon Nov 22 20:48:18 CET 2021 | 20.6 | 353.0   | 182.54  | 3645.61          | 0.07  | 5               | 577.9823654606263  | 18021.85005574136  | 0.3152943286704917  | 4330.2    | 2.38             | 115.59647309212525 | 0.06305886573409833  | 0   | 12     | ESPH1  | 9492    | GBRM   |     | 1      | 339   | n1    | 33,90    | 4,55    | 3,79     | 5,02 | 07/12/2021 0:00:00 | 02/01/2021 0:00:00 | ES              |          | 21/05/2021 0:00:00 | 658,032 |
| ES  |     | 123  | Mon Nov 22 20:56:29 CET 2021 | 14.0 | 342.0   | 84.08   | 1892.72          | 0.18  | 4               | 329.7845117845118  | 9928.445993265992  | 0.4332130926953546  | 2649.12   | 3.33             | 82.44612794612794  | 0.10830327317385     | 0   | 12     | ESPH1  | 9499    | 840M3  |     | 1      | 382   | n1    | 34,90    | 3,22    | 3,40     | 4,99 | 07/12/2021 0:00:00 | 20/11/2020 0:00:00 | ES              |          | 19/11/2021 0:00:00 | 623,461 |
| ES  |     | 364  | Mon Nov 22 21:25:18 CET 2021 | 17.7 | 353.0   | 124.63  | 2983.51          | 0.12  | 3               | 416.18426501035196 | 11718.46149068323  | 0.16710207260913496 | 2575.07   | 1.12             | 138.728088336784   | 0.0557006008         | 0   | 12     | ESPH1  | 9501    | 840M3  |     | 1      | 291   | n1    | 38,90    | 4,10    | 3,51     | 4,70 | 07/12/2021 0:00:00 | 19/02/2021 0:00:00 | ES              |          | 08/07/2021 0:00:00 | 632,368 |
| ES  |     | 253  | Mon Nov 22 21:33:45 CET 2021 | 16.4 | 386.0   | 143.62  | 3937.58          | 0.1   | 5               | 638.1588738059327  | 20841.785816728847 | 0.38961611552911024 | 6160.1    | 3.95             | 127.63177476118653 | 0.07792325           | 0   | 12     | ESPH1  | 9514    | 840M3  |     | 1      | 223   | n1    | 33,60    | 4,42    | 3,79     | 4,99 | 07/12/2021 0:00:00 | 28/04/2021 0:00:00 | ES              |          | 10/09/2021 0:00:00 | 641,056 |
| ES  |     | 179  | Mon Nov 22 21:42:08 CET 2021 | 12.1 | 603.0   | 187.48  | 2412.15          | 0.23  | 7               | 1207.601986249045  | 21018.304430863256 | 1.353011447947969   | 6426.87   | 9.86             | 172.51456946414928 | 0.19328734970        | 0   | 12     | ESPH1  | 9522    | 840M3  |     | 1      | 309   | n1    | 40,50    | 2,22    | 3,34     | 4,97 | 07/12/2021 0:00:00 | 01/02/2021 0:00:00 | ES              |          | 21/04/2021 0:00:00 | 657,193 |
| ES  |     | 153  | Mon Nov 22 21:54:12 CET 2021 | 12.3 | 239.0   | 93.29   | 3023.13          | 0.11  | 2               | 211.11226611226613 | 9635.07484074843   | 0.06837873515197078 | 3180.75   | 1.03             | 105.55613305613306 | 0.034189367579585    | 0   | 12     | ESPH1  | 9524    | 840M3  |     | 1      | 257   | n1    | 30,20    | 4,73    | 3,69     | 5,10 | 07/12/2021 0:00:00 | 25/03/2021 0:00:00 | ES              |          | 30/05/2021 0:00:00 | 564,904 |
| ES  |     | 233  | Mon Nov 22 22:00:32 CET 2021 | 12.4 | 459.0   | 65.35   | 1708.46          | 0.12  | 5               | 349.9339738923324  | 11015.28748938095  | 0.43203751793536104 | 3556.86   | 4.5              | 69.98679477846648  | 0.08560750358707221  | 0   | 12     | ESPH1  | 9525    | 840M3  |     | 1      | 305   | n1    | 39,00    | 3,44    | 3,38     | 5,04 | 07/12/2021 0:00:00 | 05/02/2021 0:00:00 | ES              |          | 20/04/2021 0:00:00 | 673,949 |
| ES  |     | 243  | Mon Nov 22 22:10:03 CET 2021 | 21.5 | 308.0   | 232.21  | 5241.77          | 0.06  | 4               | 866.969696969697   | 24427.121212121212 | 0.2342820593185971  | 8578.83   | 2.08             | 216.74242424242425 | 0.05857051482964928  | 10  | 12     | ESPH1  | 9529    | 840M3  |     | 1      | 270   | n1    | 40,70    | 4,46    | 3,79     | 4,99 | 07/12/2021 0:00:00 | 12/03/2021 0:00:00 | ES              |          | 28/05/2021 0:00:00 | 632,988 |
| ES  |     | 135  | Mon Nov 22 22:16:43 CET 2021 | 11.1 | 268.0   | 220.28  | 5748.11          | 0.06  | 4               | 569.2437160540609  | 25125.016420361248 | 0.17554566167125346 | 6377.46   | 2.02             | 142.31092901351522 | 0.043886415417813365 | 10  | 12     | ESPH1  | 9529    | 840M3  |     | 1      | 163   | n1    | 45,20    | 3,00    | 3,35     | 5,14 | 07/12/2021 0:00:00 | 27/06/2021 0:00:00 | ES              |          | 23/11/2021 0:00:00 | 631,529 |
| ES  |     | 180  | Mon Nov 22 22:22:57 CET 2021 | 10.8 | 674.0   | 140.17  | 6116.57          | 0.04  | 11              | 1423.3539729111376 | 72146.39184785487  | 0.3804216924355346  | 6294.48   | 1.72             | 129.39581571919433 | 0.03458370022141223  | 10  | 12     | ESPH1  | 9529    | 840M3  |     | 1      | 270   | n1    | 40,70    | 4,46    | 3,79     | 4,99 | 07/12/2021 0:00:00 | 12/03/2021 0:00:00 | ES              |          | 28/05/2021 0:00:00 | 632,988 |
| ES  |     | 189  | Mon Nov 22 22:36:04 CET 2021 | 13.2 | 307.0   | 128.16  | 4759.58          | 0.06  | 4               | 376.9674621709726  | 22420.723981900454 | 0.1045093253535182  | 3536.29   | 1.02             | 94.24186554274316  | 0.026127331383827956 | 10  | 12     | ESPH1  | 9529    | 840M3  |     | 1      | 163   | n1    | 45,20    | 3,00    | 3,35     | 5,14 | 07/12/2021 0:00:00 | 27/06/2021 0:00:00 | ES              |          | 23/11/2021 0:00:00 | 631,529 |
| ES  |     | 158  | Mon Nov 22 22:43:15 CET 2021 | 18.3 | 416.0   | 103.82  | 2997.8           | 0.09  | 4               | 434.45247897642204 | 15196.337130475158 | 0.2580819528163808  | 4414.04   | 2.94             | 106.61311974410566 | 0.0645204882040952   | 10  | 12     | ESPH1  | 9529    | 840M3  |     | 1      | 163   | n1    | 45,20    | 3,00    | 3,35     | 5,14 | 07/12/2021 0:00:00 | 27/06/2021 0:00:00 | ES              |          | 23/11/2021 0:00:00 | 631,529 |
| ES  |     | 246  | Mon Nov 22 22:52:00 CET 2021 | 16.4 | 671.0   | 134.73  | 3133.5           | 0.11  | 6               | 878.45424245194419 | 24473.33101922322  | 0.5466706894738621  | 4159.94   | 2.15             | 146.40903741990698 | 0.09111178157897702  | 0   | 12     | ESPH1  | 9529    | 840M3  |     | 1      | 163   | n1    | 45,20    | 3,00    | 3,35     | 5,14 | 07/12/2021 0:00:00 | 27/06/2021 0:00:00 | ES              |          | 23/11/2021 0:00:00 | 631,529 |

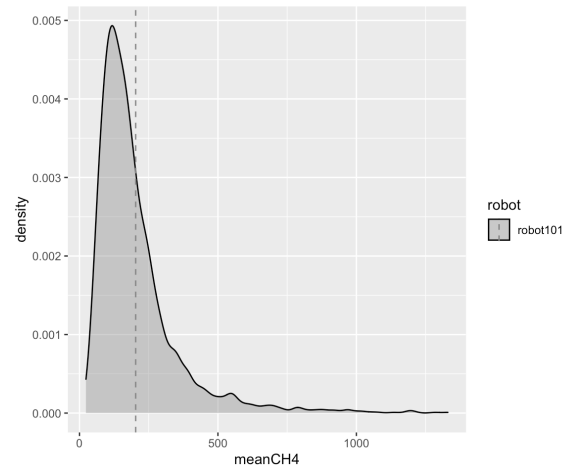
We provide a report to each farm

# Internal REPORTS

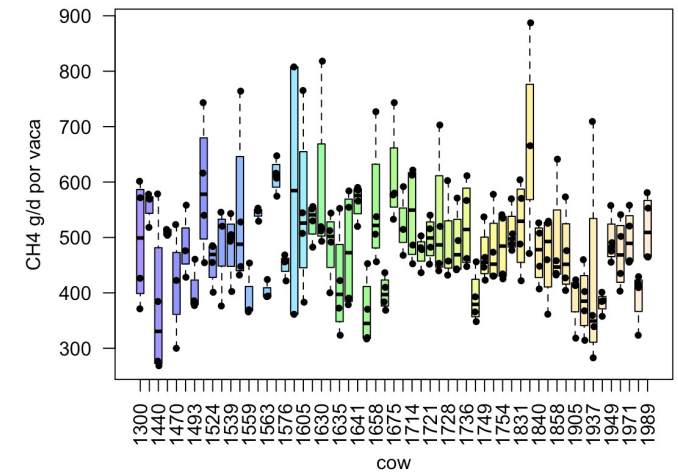
## Number of visits per cow



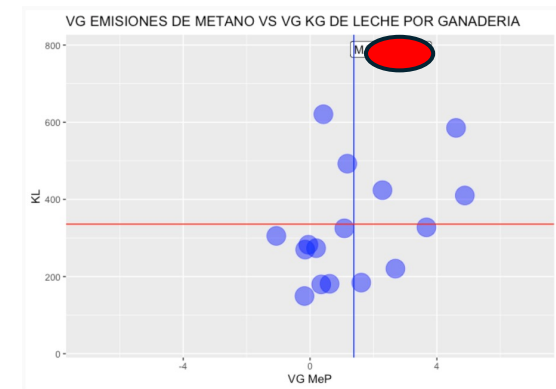
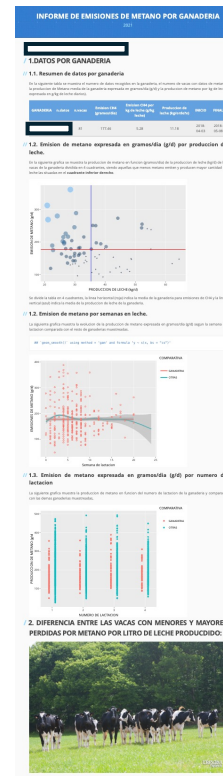
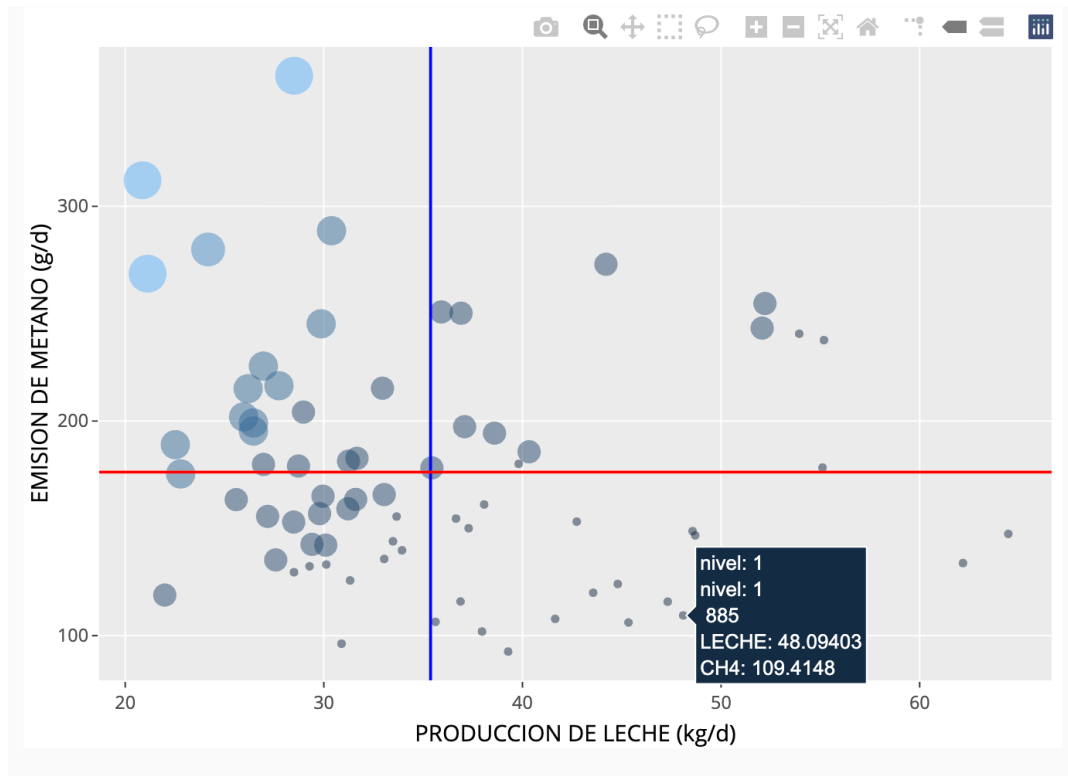
## Mean CH4 distribution



## CH4 distribution per cow

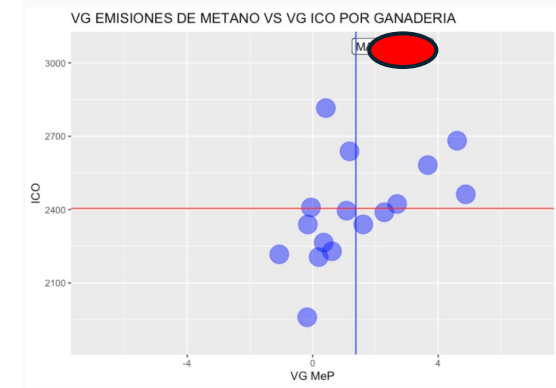


# REPORTS for the farm



## 5.2. EMISIONES DE METANO - ICO

En la siguiente grafica se muestra la comparativa entre explotaciones para la media del valor genético de emisiones de metano. Siendo el objetivo situarse en el CUADRANTE SUPERIOR IZ





Thank you!



THE UNIVERSITY of EDINBURGH  
The Royal (Dick) School  
of Veterinary Studies

# A Robust Pipeline for Nationwide Methane Sniffer Data Collection and Management

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**Lucas Alcantara, PhD**

Consultant | Alcantara Data Solutions  
Manager, Systems, Data & Research Technologies | University of Guelph



# Focus on the Upstream Process

How do we automatically and reliably get raw methane data from sniffers on dozens of remote commercial farms to a standardized central database?



# From Single Farms to National Programs

## Global Expansion

Started with **Lactanet** in Canada across Alberta and Quebec. Expanded to Ontario and British Columbia.

Successfully deploy for **Qualitas AG** in Switzerland, which later expanded to Austria and Germany.

## Operational Logic

Deployment is location agnostic, supporting **multi-region aggregation** workflows.

Ensures data integrity and process consistency across diverse geographic locations.

## Scale & Efficiency

**Repeatable architecture** enables rapid country-scale expansion.

Growth is achieved seamlessly **without the need for redesign** or technical debt.

Standardized workflows ensure consistency from individual data collection to national-level insights.



# From Single Farms to National Programs

## Canada (Lactanet)

- Started in Alberta: 10 sniffers (4 farms)
- Quebec: 25 sniffers (14 farms)
- Ontario: 14 sniffers (6 farms)
- British Columbia: 10 sniffers (2 farms)
- Holstein & Jerseys
- **Total: 59 Sniffers, ~5 partner organizations**

## Switzerland (Qualitas AG)

- Nationwide Launch: 64 sniffers (57 farms)
- DACH Region: 8 rotating sniffers across Switzerland, Austria, & Germany (7+ farms)
- Holstein & Brown Swiss
- **Total: 72 Sniffers, ~10 partner organizations**

Scaling international research through standardized methane data integration.



# The Challenge of Distributed Phenotyping

**The Need:** Deploy MooLogger (Tecnosens S.P.A.) sniffers nationwide

**The Goal:** Turn high-frequency sensor streams into a centralized, queryable asset for geneticists

## Key Infrastructure Challenges



**Private Networks**



**Unstable  
Connectivity**



**Power Outages**

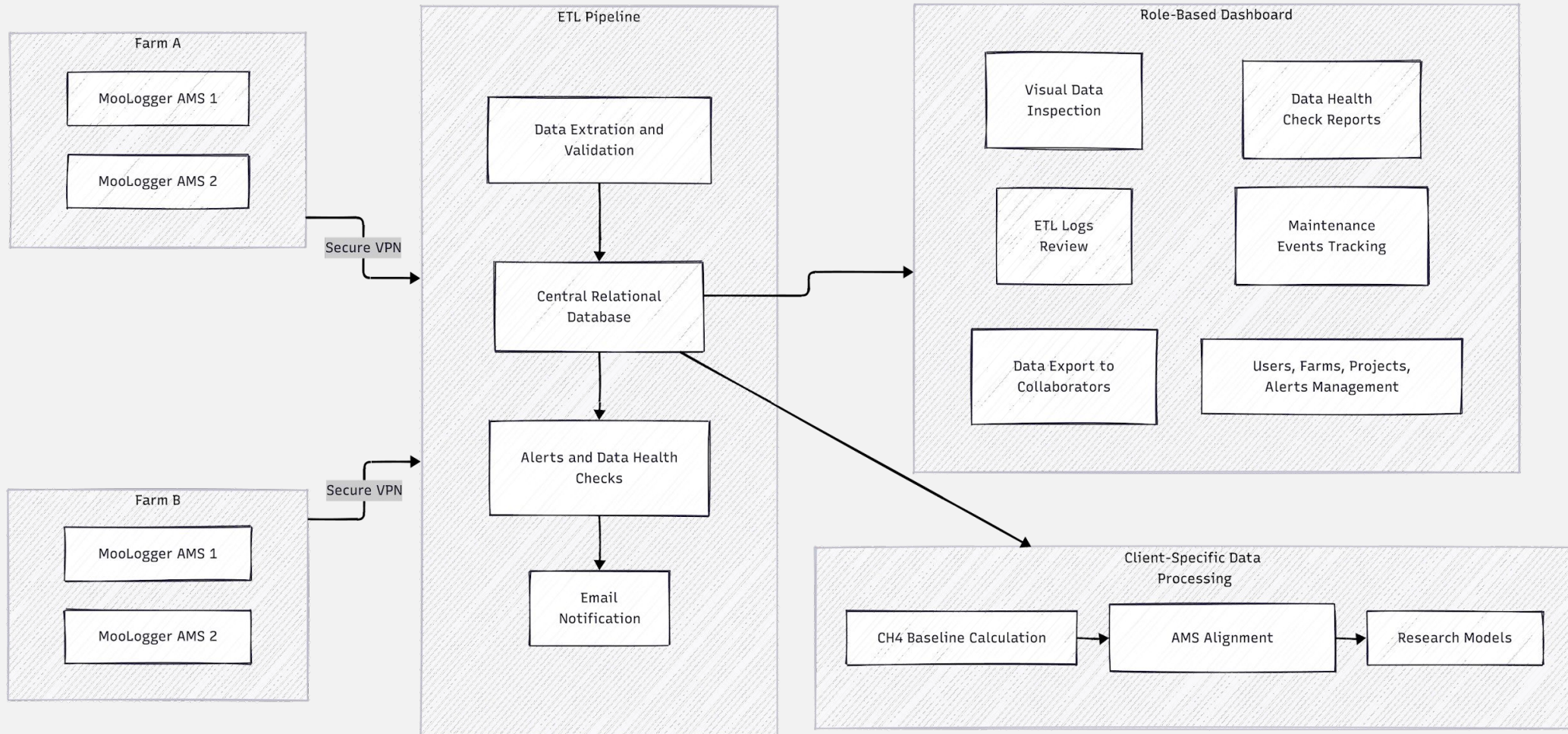


**Harsh Environments**

Sensor Streams: CH<sub>4</sub>, CO<sub>2</sub>, Flow, Temperature, Humidity



# End-To-End Path Overview



# Connectivity: Bridging the Farm-To-Cloud Gap

**VPN Integration:** Every sniffer is a node on a private national network.

## Benefits

- No port forwarding required on farm routers.
- Static IP addresses specific to each sniffer independent from farm network.
- Secure SSH and API access for remote troubleshooting and data collection.

## Uptime Monitoring

- Real-time ICMP ping
- API health checks integrated into the management layer

# The ETL Engine: Built for Reliability



## Dual-Path Ingestion

### Early versions (MooLogger):

Direct PostgreSQL extraction

### Current versions (MooLogger Plus):

Pulling data via MooLogger API



## Fault Tolerance

### Auto-Catchup:

System tracks "last extracted date" per sniffer.

### Exactly-Once Semantics:

Prevention of duplicate records during reconnection bursts.

### Batch Processing:

Concurrent extraction threads to handle dozens of devices simultaneously.



# Preventing Silent Failures Before Analysis

## Activity Monitoring

Checks for recording activity verify reachability, freshness, and growth behavior.

Daily summaries and periodic status check throughout the day balance broad review and rapid response.

## Advanced Alert Logic

Absolute-value alerts use banded ranges for CH<sub>4</sub>, CO<sub>2</sub>, airflow, temperature, and humidity.

Percent-change alerts detect sniffer-specific changes against their own rolling baseline.

## Triage & Severity Protocol

Standardized severity levels support practical triage and operational focus:

**SUCCESS** **WARNING** **ERROR** **CRITICAL**



# Management at Multi-Institution Scale

## Access & Permissions

Role-based access controls who sees and receives which data, and who can add/edit events.

Technical support can have access, but does not receive alert notifications.

## Project-Level Scoping

Project-level scoping keeps notifications relevant and reduces alert fatigue by narrowing the operational field.

## Institutional Governance

Governance supports clean boundaries across institutions and funded projects, ensuring operational independence while maintaining centralized oversight capabilities.



# Upstream Robustness Improves Downstream Processing



## Faster Detection

Faster issue detection reduces risk of losing data due to bad quality.



## Routine Checks

Issues detected during routine checks can be flagged as an event and accounted for during analysis.



## Immediate Alerts

Alert notifications throughout the day can be the difference between one hour or one day data lost.

Proactive monitoring ensures data integrity and minimizes impact on downstream analytical workflows.





100% (2/2)

All checked sniffers passed last data check.  
Last check: 2026-04-28 06:04:32 AM EDT | Next in 03:23:37

✓ 2026-04-27

Last date extracted. Pipeline is up to date.

100%

All sniffers had yesterday's data extracted.

! 50% (1/2)

Sniffers with complete records from yesterday.

### Data Pipeline Overview

Extraction Date Range:

2026-04-20 to 2026-04-28

Measure Date Range:

2026-04-20 to 2026-04-27

Sniffer

DEV-ML244901 (Dev Farm - 1)

Summary

Missing Data

Incomplete Data

Recording Activity

Sniffer-Specific Logs

Main System Logs

| Extraction Timestamp ↑     | Farm ↓   | Sniffer ↓    | Robot Number | Measure Date ↑ | Rows Extracted | Rows Uploaded | Extraction Duration | Upload Duration |
|----------------------------|----------|--------------|--------------|----------------|----------------|---------------|---------------------|-----------------|
| 2026-04-28 12:06:53 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-27     | 442,866        | 442,866       | 1.71 min            | 0.14 min        |
| 2026-04-27 12:07:11 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-26     | 518,412        | 518,412       | 1.99 min            | 0.18 min        |
| 2026-04-26 12:07:30 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-25     | 518,400        | 518,400       | 2.04 min            | 0.25 min        |
| 2026-04-25 12:07:07 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-24     | 518,412        | 518,412       | 2.08 min            | 0.18 min        |
| 2026-04-24 12:07:06 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-23     | 518,412        | 518,412       | 2.01 min            | 0.26 min        |
| 2026-04-23 12:07:10 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-22     | 518,400        | 518,400       | 2 min               | 0.15 min        |
| 2026-04-22 12:07:07 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-21     | 518,412        | 518,412       | 2.05 min            | 0.15 min        |
| 2026-04-21 12:07:59 AM EDT | Dev Farm | DEV-ML244901 | 1            | 2026-04-20     | 518,406        | 518,406       | 2.93 min            | 0.17 min        |





100% (2/2)

All checked sniffers passed last data check.  
Last check: 2026-04-28 06:04:32 AM EDT | Next in 03:23:31

✓ 2026-04-27

Last date extracted. Pipeline is up to date.

100%

All sniffers had yesterday's data extracted.

! 50% (1/2)

Sniffers with complete records from yesterday.

### Data Pipeline Overview

Extraction Date Range:

2026-04-20 to 2026-04-28

Measure Date Range:

2026-04-20 to 2026-04-27

Sniffer

DEV-ML244901 (Dev Farm - 1)

Summary

Missing Data

Incomplete Data

Recording Activity

Sniffer-Specific Logs

Main System Logs

Farm

Sniffer

Robot Number

Measure Date

No data available

**i** Missing Data: Sniffer was not reachable during data extraction.  
If sniffer was offline and recording data, data will be extracted on the next extraction cycle.  
If sniffer was turned off or offline, but not recording data, there is no data to be extracted.



Welcome, Lucas Alcantara! Logout

**100% (2/2)**  
All checked sniffers passed last data check.  
Last check: 2026-04-28 06:04:32 AM EDT | Next in 03:24:55

**✓ 2026-04-27**  
Last date extracted. Pipeline is up to date.

**100%**  
All sniffers had yesterday's data extracted.

**!50% (1/2)**  
Sniffers with complete records from yesterday.

### Data Pipeline Overview

**Extraction Date Range:** 2026-04-20 to 2026-04-28 |
 **Measure Date Range:** 2026-04-20 to 2026-04-27 |
 **Sniffer:** DEV-ML244901 (Dev Farm - 1)

Summary | Missing Data | **Incomplete Data** | Recording Activity | Sniffer-Specific Logs | Main System Logs

| Farm     | Sniffer      | Robot Number | Measure Date | Rows Uploaded | Software Version |
|----------|--------------|--------------|--------------|---------------|------------------|
| Dev Farm | DEV-ML244901 | 1            | 2026-04-27   | 442,866       | 2.6.1            |

**Incomplete Data:**  
 MooLogger: < 774k rows (SW version <= 1)  
 MooLogger Plus: < 516k rows (SW version >= 2)

Sniffer Dashboard by Alcantara Data Solutions 2026



100% (2/2)

All checked sniffers passed last data check.  
Last check: 2026-04-28 06:04:32 AM EDT | Next in 03:26:14

✓ 2026-04-27

Last date extracted. Pipeline is up to date.

100%

All sniffers had yesterday's data extracted.

!50% (1/2)

Sniffers with complete records from yesterday.

### Data Pipeline Overview

Extraction Date Range:

2026-04-20 to 2026-04-28

Measure Date Range:

2026-04-20 to 2026-04-27

Sniffer

DEV-ML244901 (Dev Farm - 1)

Summary

Missing Data

Incomplete Data

Recording Activity

Sniffer-Specific Logs

Main System Logs

Data Check Date Range

2026-04-21 to 2026-04-28

Network Connection

All

API Connection

All

Up to Date

All

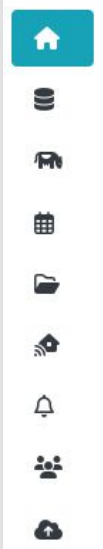
Records Increased

All

Search...

| Sniffer      | Robot Number | Network Connection | Ping Latency | API Connection | Max Measure Timestamp      | Time Difference | Up to Date | Total Records | Records Increased |
|--------------|--------------|--------------------|--------------|----------------|----------------------------|-----------------|------------|---------------|-------------------|
| DEV-ML244901 | 1            | ✓ Successful       | 232 ms       | ✓ Successful   | 2026-04-28 06:04:33 AM EDT | 0d 0h 0m        | ✓ Yes      | 36275         | ✓ Yes             |
| DEV-ML244901 | 1            | ✓ Successful       | 182 ms       | ✓ Successful   | 2026-04-28 12:04:46 AM EDT | 0d 0h 0m        | ✓ Yes      | 14687         | ✓ Yes             |
| DEV-ML244901 | 1            | ✗ Failed           | N/A          | ✗ Failed       | N/A                        | N/A             | N/A        | N/A           | N/A               |
| DEV-ML244901 | 1            | ✓ Successful       | 180 ms       | ✓ Successful   | 2026-04-27 12:04:16 PM EDT | 0d 0h 0m        | ✓ Yes      | 57858         | ✓ Yes             |





**100% (2/2)**

All checked sniffers passed last data check.  
Last check: 2026-04-28 06:04:32 AM EDT | Next in 03:23:15

**✓ 2026-04-27**

Last date extracted. Pipeline is up to date.

**100%**

All sniffers had yesterday's data extracted.

**!50% (1/2)**

Sniffers with complete records from yesterday.

### Data Pipeline Overview

**Extraction Date Range:** 2026-04-20 to 2026-04-28 |
 **Measure Date Range:** 2026-04-20 to 2026-04-27 |
 **Sniffer:** DEV-ML244901 (Dev Farm - 1)

Summary | Missing Data | Incomplete Data | Recording Activity | **Sniffer-Specific Logs** | Main System Logs

Search...

| Extraction Timestamp       | Log Level | Farm     | Sniffer      | Robot Number | Log Message  |
|----------------------------|-----------|----------|--------------|--------------|--|
| 2026-04-28 06:04:47 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | **** Done! ****  |
| 2026-04-28 06:04:43 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | Total days uploaded to database: 0   |
| 2026-04-28 06:04:39 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | [API] Max timestamp: 2026-04-28 10:04:33.897973+00:00   total_records=36275        |
| 2026-04-28 06:04:38 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | Max timestamp recorded: 2026-04-28 10:04:33.897973+00:00 with 36,275 total records |
| 2026-04-28 06:04:30 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | Retrieving summarized dates...   |
| 2026-04-28 06:00:14 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | Retrieving uploaded dates...   |
| 2026-04-28 06:00:13 AM EDT | INFO      | Dev Farm | DEV-ML244901 | 1            | MooLogger's Software version unchanged   |

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- Farms
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- Users
- Data Export

Date Range:

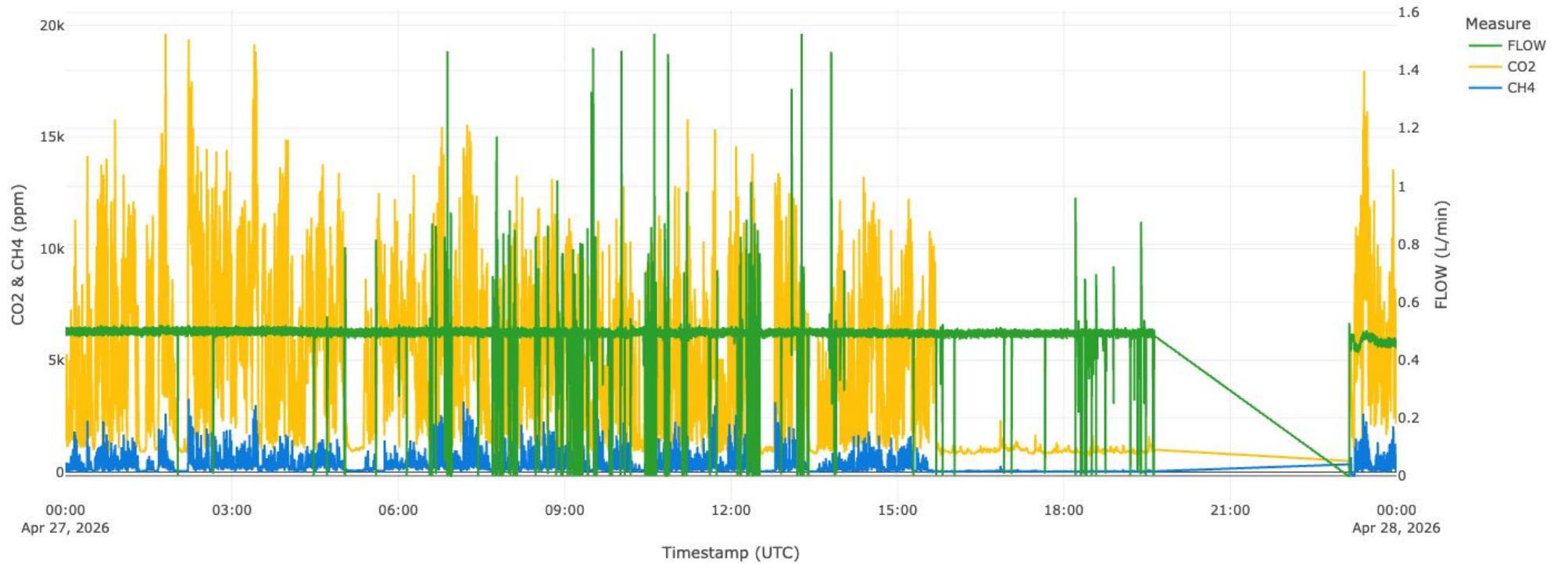
2026-04-27 to 2026-04-27

Sniffer:

DEV-ML244901 (Dev Farm - 1)

Generate Plot

DEV-ML244901 (Dev Farm - 1)





Menu

Welcome, Lucas Alcantara!

Logout



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- Alerts
- Users
- Data Export <

Add

Event Date (EST):

2026-04-28 08:48 PM

Device:

DEV-ML244901 (Dev Farm - 1) v

Event Name:

Select v

Event Comment:

(Optional) Enter a comment for this event

Add Event

- Search...
- Maintenance
  - Calibration
  - Calibration zero
  - Filter cleaning
  - Flowmeter replacement
  - Nose maintenance**
  - Pump replacement
  - Water filter installation
  - Data pipeline
  - Data collection started





Alerts

Settings



Missing Data

Diverging Records

Incomplete Rows

Recording Activity

Data Quality

Configure alerts based on CH4, CO2, CH4/CO2 ratio, Air Flow, Temperature, and Humidity. These alerts monitor absolute values and percent changes from baseline values.

Absolute Values

Percent Changes

### Baseline Configuration

Configure baseline settings for percent change calculations. These settings apply to all percent change alert levels and measurements.

Number of days for baseline

Minimum days required

Statistic to use

Percent change alerts evaluate the percentage change from baseline values. Each alert level (Success, Warning, Error, Critical) can occur on both sides of the baseline - for values smaller (negative percent change) or larger (positive percent change) than the baseline. For example, if Success is 0-5%, then a value that is 4% smaller OR 4% larger than the baseline would both trigger Success alerts. Both bounds are inclusive. Higher severity levels are prioritized when ranges overlap. Empty fields default to 0.0.

| Measurement | Success                          |                                  | Warning                          |                                   | Error                             |                                   | Critical                          |                                    | Enable/Disable Status               |                                     |                          |                          |
|-------------|----------------------------------|----------------------------------|----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|-------------------------------------|-------------------------------------|--------------------------|--------------------------|
|             | Min %                            | Max %                            | Min %                            | Max %                             | Min %                             | Max %                             | Min %                             | Max %                              | Success                             | Warning                             | Error                    | Critical                 |
| CH4         | <input type="text" value="0.0"/> | <input type="text" value="5.0"/> | <input type="text" value="5.0"/> | <input type="text" value="10.0"/> | <input type="text" value="10.0"/> | <input type="text" value="20.0"/> | <input type="text" value="70.0"/> | <input type="text" value="100.0"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| CO2         | <input type="text" value="0.0"/> | <input type="text" value="5.0"/> | <input type="text" value="5.0"/> | <input type="text" value="10.0"/> | <input type="text" value="10.0"/> | <input type="text" value="20.0"/> | <input type="text" value="70.0"/> | <input type="text" value="100.0"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |





Menu

Welcome, Lucas Alcantara!

Logout



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- Data Export**
- Target Servers
- SSH Keys
- Project Links
- Sync Logs

### Add/Edit Server

**Server Name:** 
**Host:** 
**Port:** 
**Username:** 
**Remote Path Destination:** 
**Description:** 
**Protocol:**  **Enabled**

### External Servers

| Status     | Server Name                | Host            | Protocol | Port | Username     | Remote Path Destination | Description   |
|------------|----------------------------|-----------------|----------|------|--------------|-------------------------|---------------|
| ▼ Disabled | alcantara                  | 100.81.193.51   | rsync    | 22   | sniffer_sync | /home/sniffer_sync/data | Test Settings |
| Event      | Timestamp                  | By              |          |      |              |                         |               |
| Created    | 2026-01-03 10:16:48 AM EST | Lucas Alcantara |          |      |              |                         |               |
| Updated    | 2026-04-28 20:45:31 PM EDT | Lucas Alcantara |          |      |              |                         |               |





Menu

Welcome, Lucas Alcantara!

Logout



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  - Target Servers
  - SSH Keys
  - Project Links
  - Sync Logs

### Sync Log Filters

#### Sync Date Range (EST):

2026-03-01 to 2026-03-31

Apply Filters

### Sync Logs

Summary

Development Project

| Sync Timestamp ↓           | Sniffer ↓ | Measure Date ↓ | Server ↓  | Source ↓ | Status ↓ | Bytes (MB) ↓ | Duration (s) ↓ | Exit Code ↓ | Error Message ↓ |
|----------------------------|-----------|----------------|-----------|----------|----------|--------------|----------------|-------------|-----------------|
| 2026-03-03 05:00:14 AM EST | ML252604  | 2026-03-02     | alcantara | psql     | success  | 2.27         | 0.8            | 0           | —               |
| 2026-03-03 05:00:02 AM EST | ML244901  | 2026-03-02     | alcantara | psql     | success  | 2.37         | 0.81           | 0           | —               |
| 2026-03-02 05:00:14 AM EST | ML252604  | 2026-03-01     | alcantara | psql     | success  | 2.33         | 0.88           | 0           | —               |
| 2026-03-02 05:00:02 AM EST | ML244901  | 2026-03-01     | alcantara | psql     | success  | 2.38         | 0.77           | 0           | —               |
| 2026-03-01 05:00:11 AM EST | ML252604  | 2026-02-28     | alcantara | psql     | success  | 2.34         | 0.84           | 0           | —               |
| 2026-03-01 05:00:02 AM EST | ML244901  | 2026-02-28     | alcantara | psql     | success  | 2.38         | 0.82           | 0           | —               |



**Thank you!**  
**Questions?**

---

**Lucas Alcantara, PhD**

Consultant | Alcantara Data Solutions  
Manager, Systems, Data & Research Technologies | University of Guelph

lucas@alcantaradata.com



# GEDA

An adaptive framework for automated processing of  
sniffer-based measurements

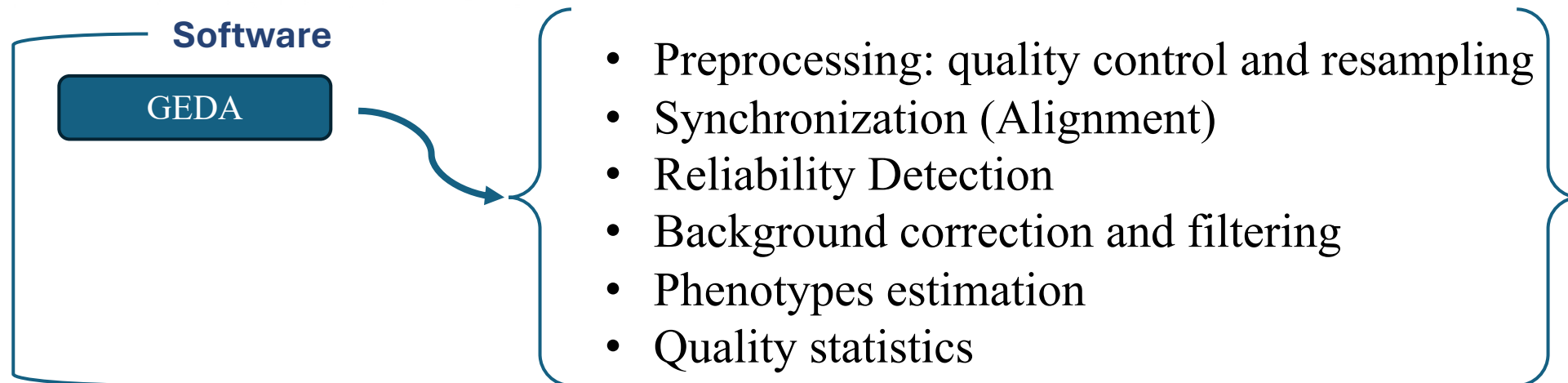
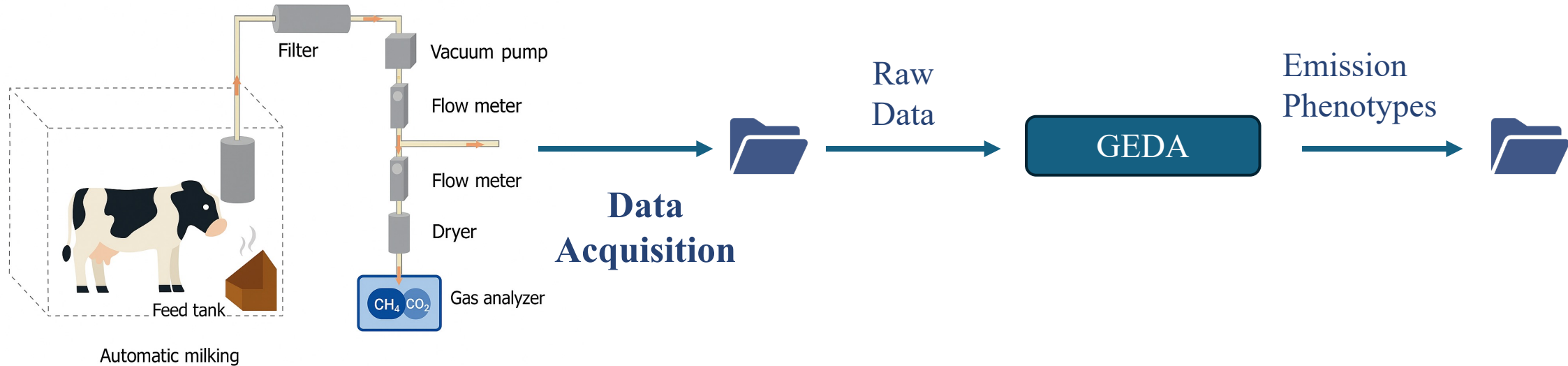
**GMG webinar: Sniffer data aligning and editing pipelines**

April 29, 2026

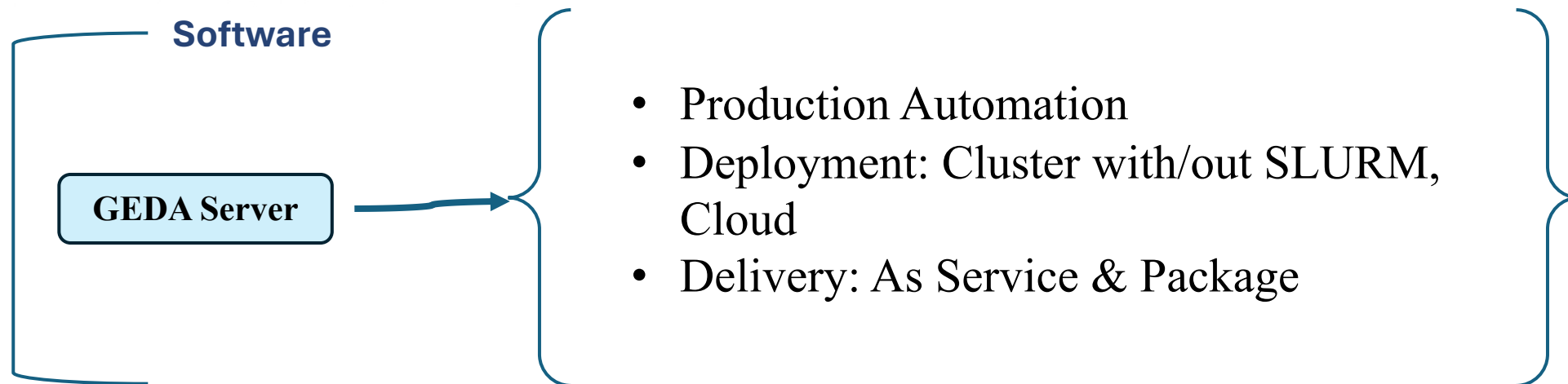
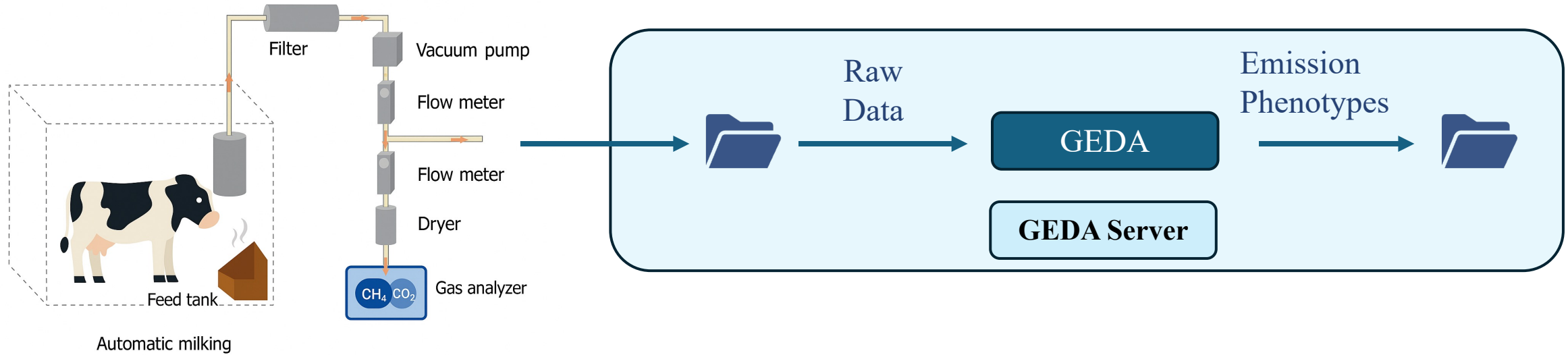
# Outline

- Framework Overview
- GEDA Interface
- Processing Stages
- Results & Summary

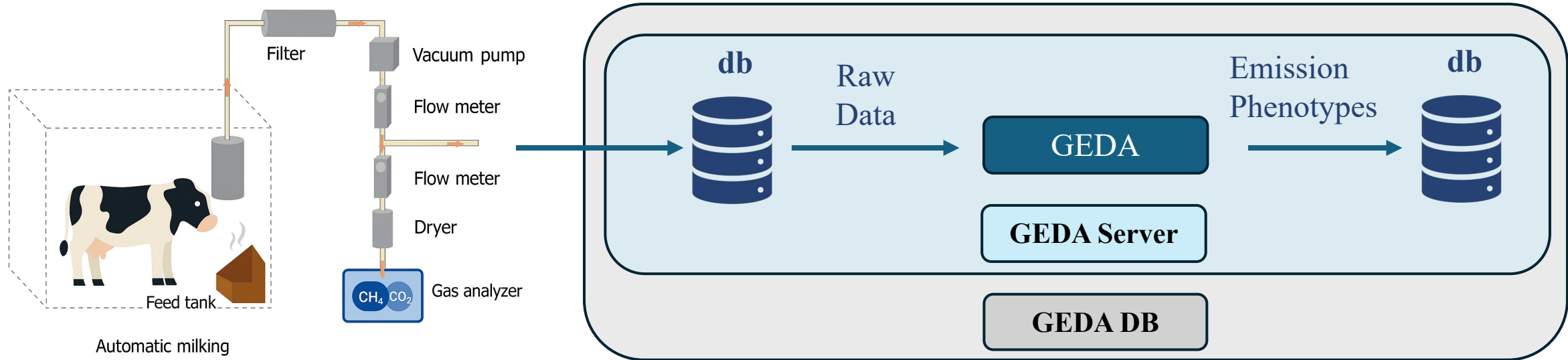
# Framework Overview



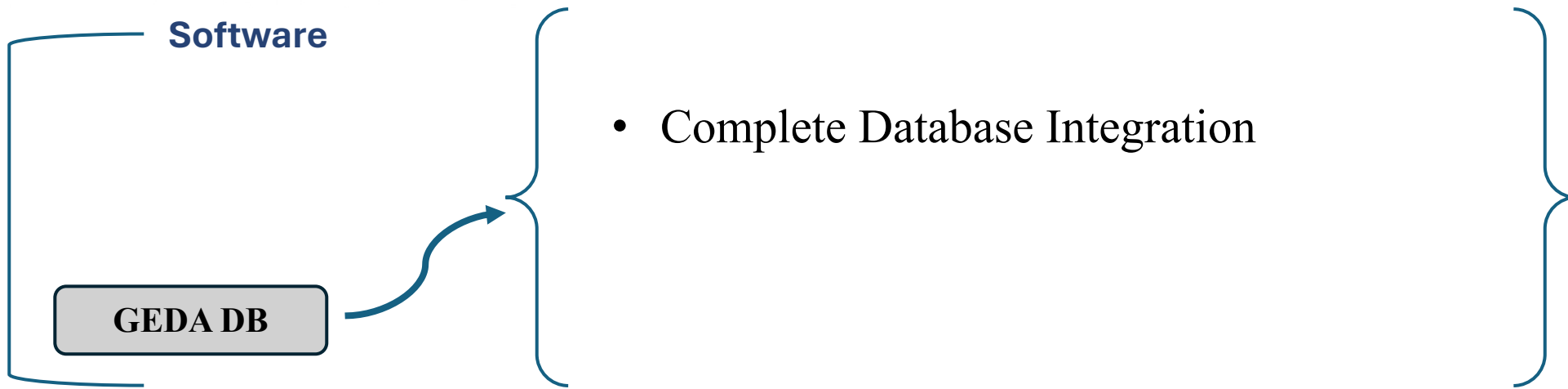
# Framework Overview



# Framework Overview



Automatic milking

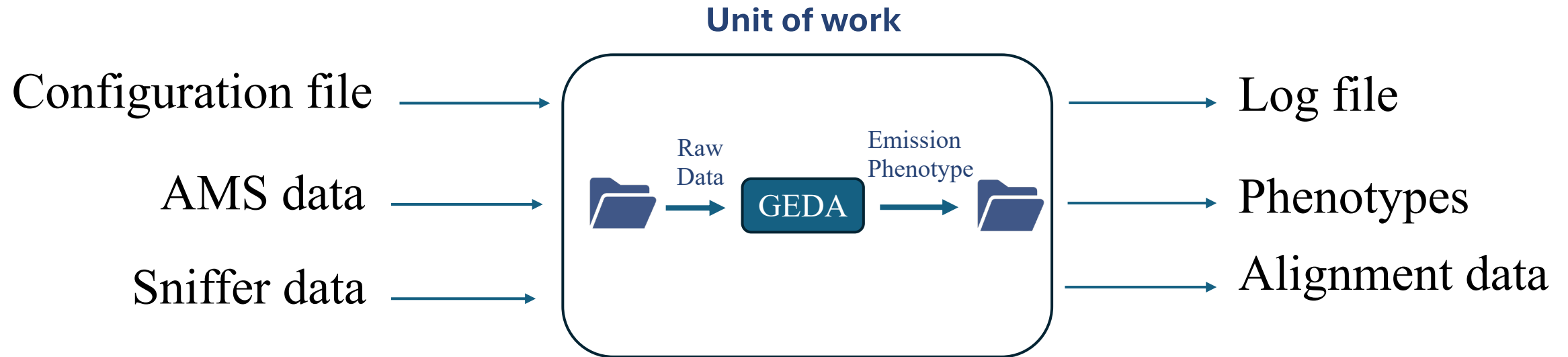


Software

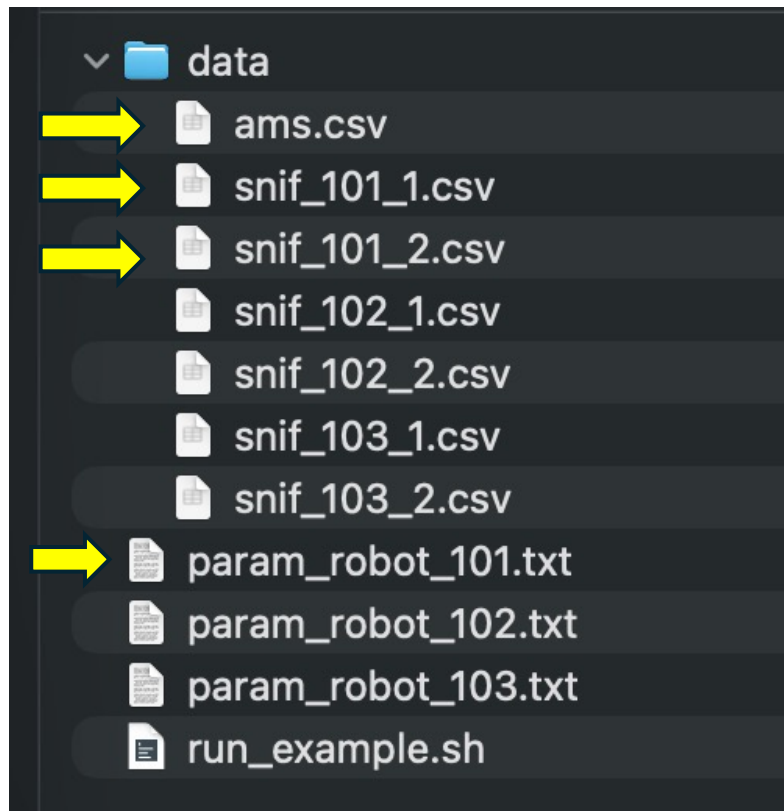
- Complete Database Integration

GEDA DB

# Interface



# Configuration File



```

param_robot_101.txt ←
$AMSFIL
data/ams.csv

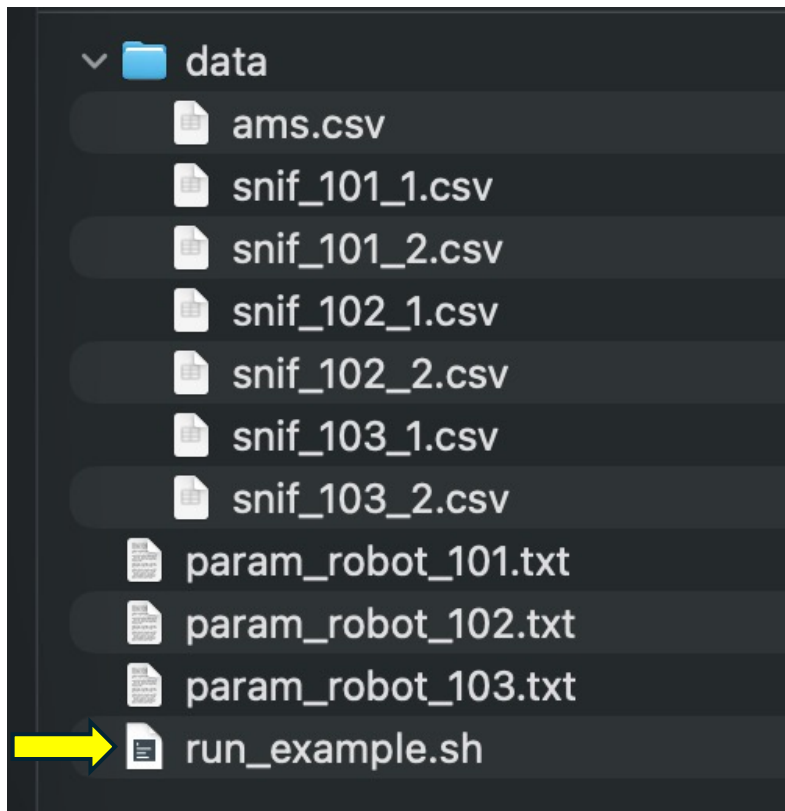
$SNIFFIL
data/snif_101_1.csv, data/snif_101_2.csv

$AMSCOLS
# strict order (min. first four cols, 5-th is optional):
# id, t1, t2, robot, farm
1, 3, 4, 2

$SNFCOLS
# strict order (min. first four cols, cols from 5-th to 7-th are optional):
# date, time, ch4, co2, farm, robot, sniff
1, 2, 3, 4

$ROBOTID
101
  
```

# Configuration File



```
run_example.sh
#!/bin/sh
for i in param_robot_101.txt param_robot_102.txt param_robot_103.txt
do
    ../bin/geda $i
done
```

A screenshot of a terminal window titled 'run\_example.sh'. The terminal shows the following script content: `#!/bin/sh`, `for i in param_robot_101.txt param_robot_102.txt param_robot_103.txt`, `do`,  `../bin/geda $i`, `done`. A yellow arrow points to the terminal title bar.

# AMS and Sniffer Data Files

| AMS data file content  | In parameter file |
|--|-------------------|
| <b>Ckrdyrn</b> ; <b>DviStartTime</b> ; <b>DviEndTime</b> ; <b>DevAddress</b> | \$AMCOLS          |
| 2608906625; 2021-11-22 23:59:44; 2021-11-23 00:04:19; 101                    | 1, 2, 3, 4        |
| 2608905499; 2021-11-23 00:05:45; 2021-11-23 00:12:43; 101                    |                   |
| 2608907322; 2021-11-23 00:34:59; 2021-11-23 00:41:53; 101                    | \$ROBOTID         |
| 2608906807; 2021-11-23 00:42:03; 2021-11-23 00:42:13; 101                    | 101               |
| 2608905851; 2021-11-23 00:42:40; 2021-11-23 00:49:19; 101                    |                   |
| 2608905269; 2021-11-23 00:49:26; 2021-11-23 00:49:38; 101                    |                   |
| 2608906299; 2021-11-23 00:49:45; 2021-11-23 00:59:43; 101                    |                   |
| 2608905812; 2021-11-23 00:59:50; 2021-11-23 01:05:56; 101                    |                   |

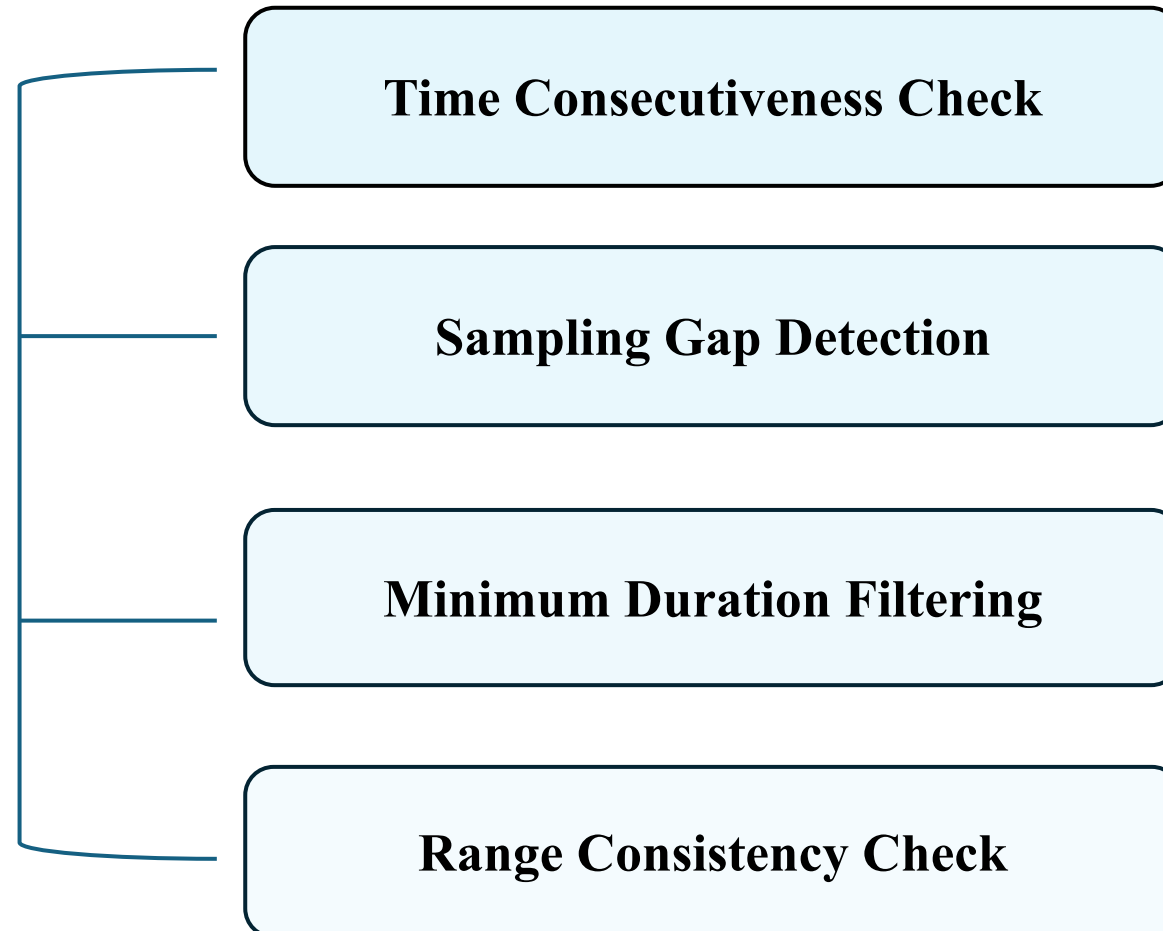
# AMS and Sniffer Data Files

| Sniffer data file content   | In parameter file               |
|---|---------------------------------|
| <pre>"DATE";"TIME";"CH4";"CO2";"Indgang";"Udgang" "06-02-2017";"16:16:11";"-0,002";"0,804";"1,000";"0,000" "06-02-2017";"16:16:12";"-0,002";"0,813";"1,000";"0,000" "06-02-2017";"16:16:13";"-0,002";"0,821";"1,000";"0,000" "06-02-2017";"16:16:14";"-0,002";"0,825";"1,000";"0,000" "06-02-2017";"16:16:15";"-0,002";"0,827";"1,000";"0,000" "06-02-2017";"16:16:16";"-0,002";"0,823";"1,000";"0,000" "06-02-2017";"16:16:17";"-0,002";"0,808";"1,000";"0,000" "06-02-2017";"16:16:18";"-0,002";"0,737";"1,000";"0,000" "06-02-2017";"16:16:19";"-0,001";"0,598";"1,000";"0,000" "06-02-2017";"16:16:20";"-0,001";"0,571";"1,000";"0,000" "06-02-2017";"16:16:21";"0,000";"0,550";"1,000";"0,000" "06-02-2017";"16:16:22";"0,001";"0,535";"1,000";"0,000" "06-02-2017";"16:16:23";"0,001";"0,504";"1,000";"0,000" "06-02-2017";"16:16:24";"0,001";"0,488";"1,000";"0,000" "06-02-2017";"16:16:25";"0,001";"0,463";"1,000";"0,000"</pre> | <pre>\$SNFCOLS 1, 2, 3, 4</pre> |

# Output Files

| Log File  | Aligned Data File  | Phenotypes File  |  |
|---|--|--|--|
| <ul style="list-style-type: none"> <li>• Run-time messages, and warnings.</li> <li>• Processing stage summaries.</li> <li>• Processed data statistics.</li> </ul> | <ul style="list-style-type: none"> <li>• Time</li> <li>• Cow ID</li> <li>• CH4</li> <li>• CO2</li> <li>• AMS robot ID</li> <li>• Sniffer device ID</li> <li>• Farm ID</li> <li>• Signal</li> </ul> | <p>Trait 11 and 21</p>   | <p>Trait 12 and 22</p>   |
|   |  | <ul style="list-style-type: none"> <li>• Cow ID</li> <li>• Farm ID</li> <li>• AMS robot ID</li> <li>• Sniffer device ID</li> <li>• Date</li> <li>• CH4</li> <li>• CO2</li> </ul> | <ul style="list-style-type: none"> <li>• Cow ID</li> <li>• Farm ID</li> <li>• AMS robot ID</li> <li>• Sniffer device ID</li> <li>• Date</li> <li>• CH4</li> <li>• CO2</li> <li>• bkgCH4</li> <li>• bkgCO2</li> </ul> |

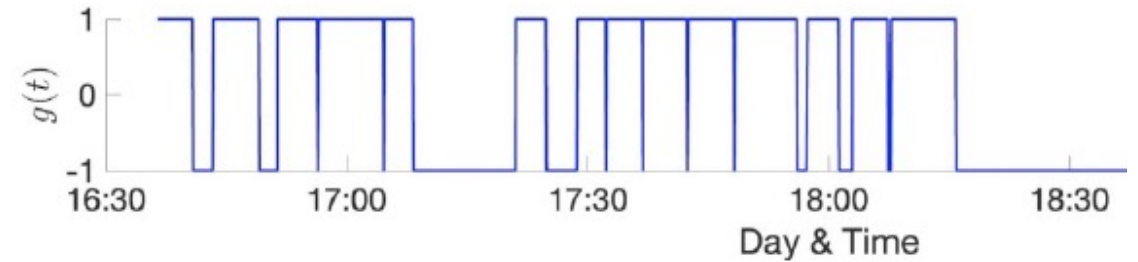
# Preprocessing



# Data Transformation and Resampling

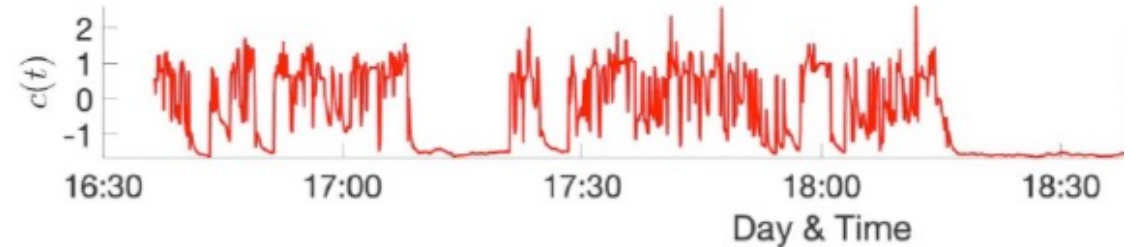
| Animal_ID;   | StartTime;           | EndTime;             | Robot |
|--------------|----------------------|----------------------|-------|
| 11003802293; | 2019-09-18 23:56:15; | 2019-09-19 00:07:53; | 101   |
| 11003802763; | 2019-09-19 00:08:34; | 2019-09-19 00:19:35; | 101   |
| 11003802158; | 2019-09-19 00:20:21; | 2019-09-19 00:34:19; | 101   |
| 11003802626; | 2019-09-19 00:41:38; | 2019-09-19 00:51:39; | 101   |
| 11003802100; | 2019-09-19 00:52:18; | 2019-09-19 00:59:15; | 101   |
| 11003802583; | 2019-09-19 00:59:56; | 2019-09-19 01:07:25; | 101   |
| 11003802345; | 2019-09-19 01:08:16; | 2019-09-19 01:17:43; | 101   |
| 11003802654; | 2019-09-19 01:18:25; | 2019-09-19 01:23:16; | 101   |

$f_{AMS}$   
 $\longrightarrow$   
 1 sec

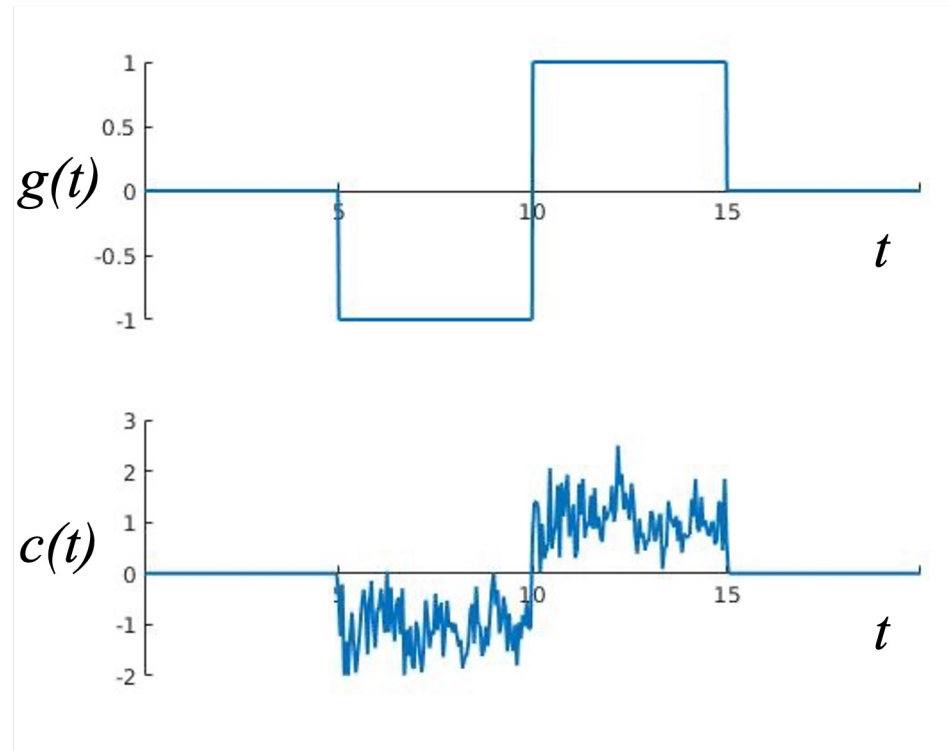


| "DATE";       | "TIME";     | "CH4"; | "CO2"   |
|---------------|-------------|--------|---------|
| "15-11-2019"; | "03:53:01"; | "-1";  | "0,383" |
| "15-11-2019"; | "03:53:02"; | "-1";  | "0,556" |
| "15-11-2019"; | "03:53:03"; | "-1";  | "0,672" |
| "15-11-2019"; | "03:53:04"; | "-1";  | "0,714" |
| "15-11-2019"; | "03:53:05"; | "-1";  | "0,775" |
| "15-11-2019"; | "03:53:06"; | "-1";  | "0,815" |
| "15-11-2019"; | "03:53:07"; | "-1";  | "0,829" |
| "15-11-2019"; | "03:53:08"; | "-1";  | "0,846" |

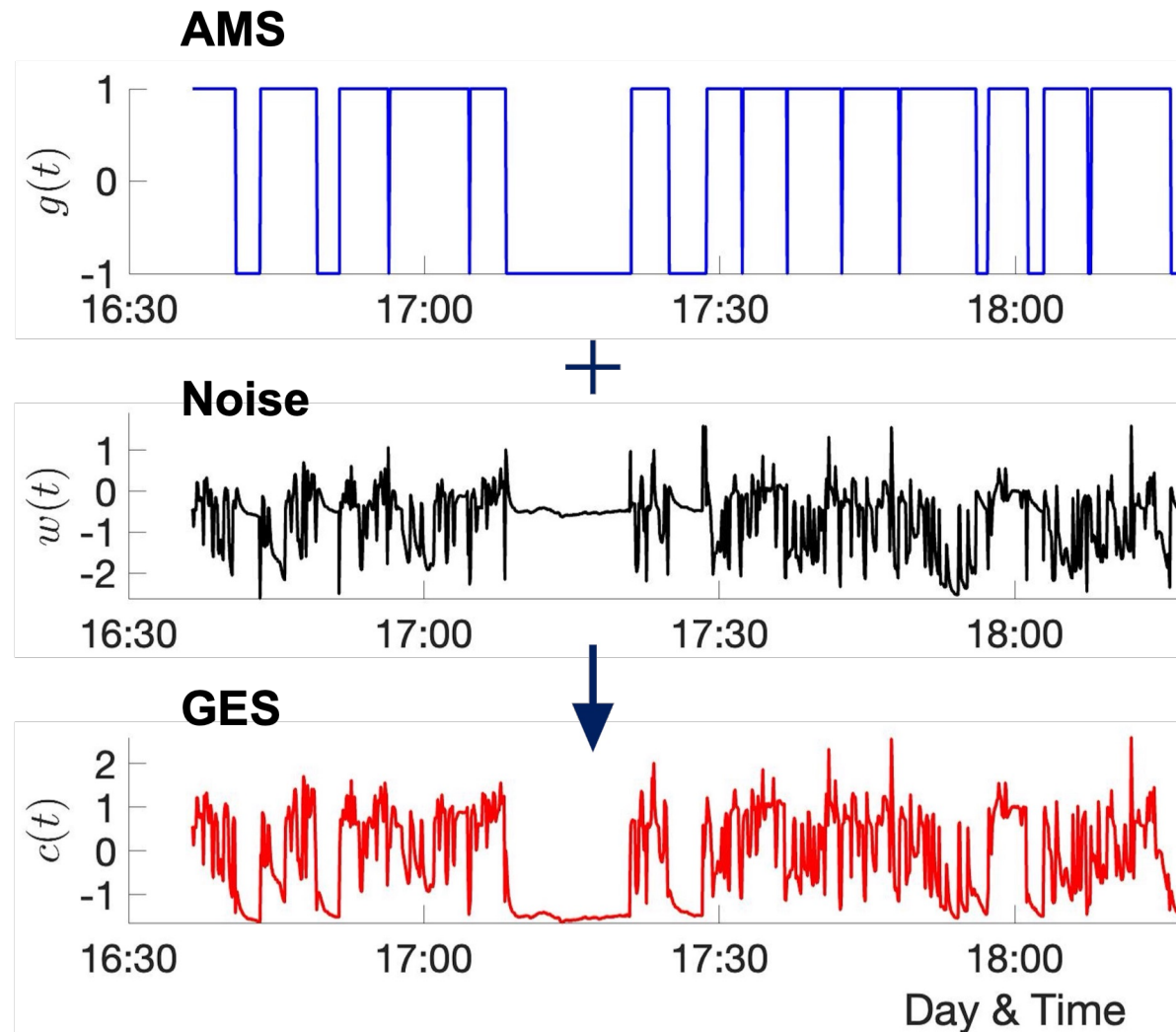
$f_{GES_1}$   
 $\longrightarrow$   
 1 sec  
 $f_{CO_2}$   
 $\longrightarrow$   
 [-1,1]



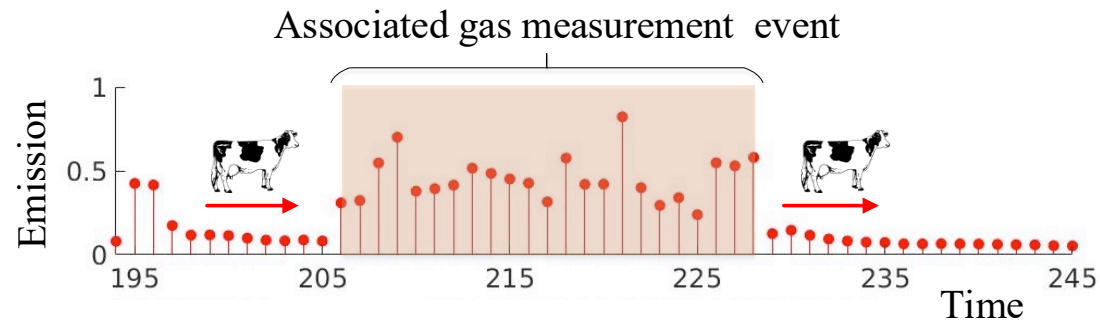
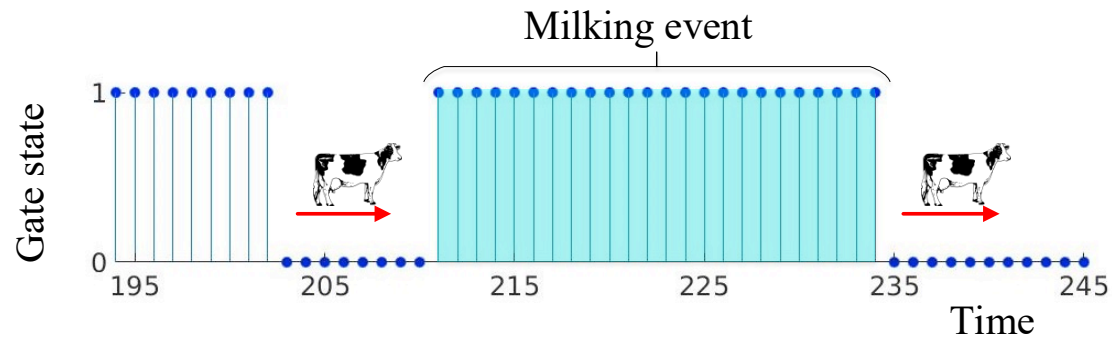
# Data Model



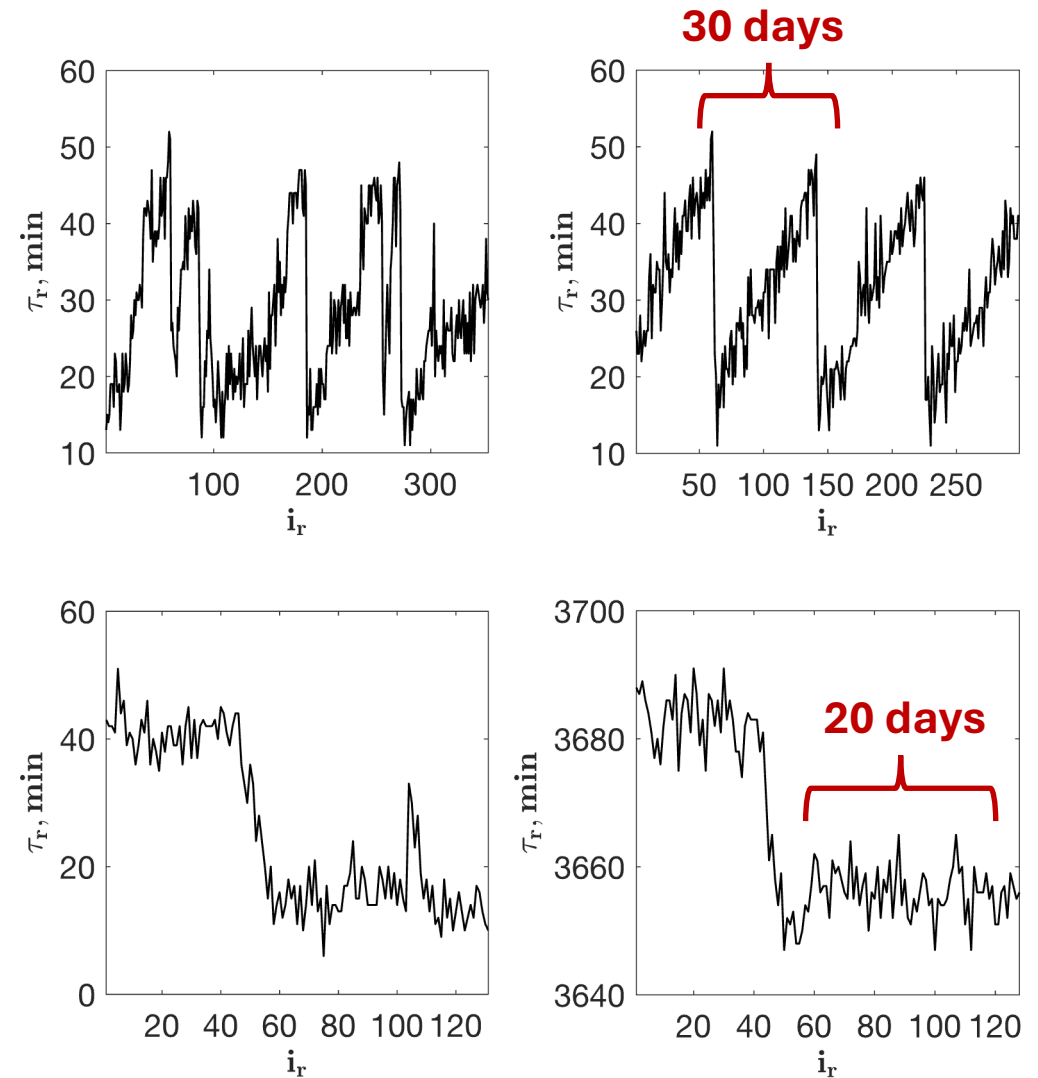
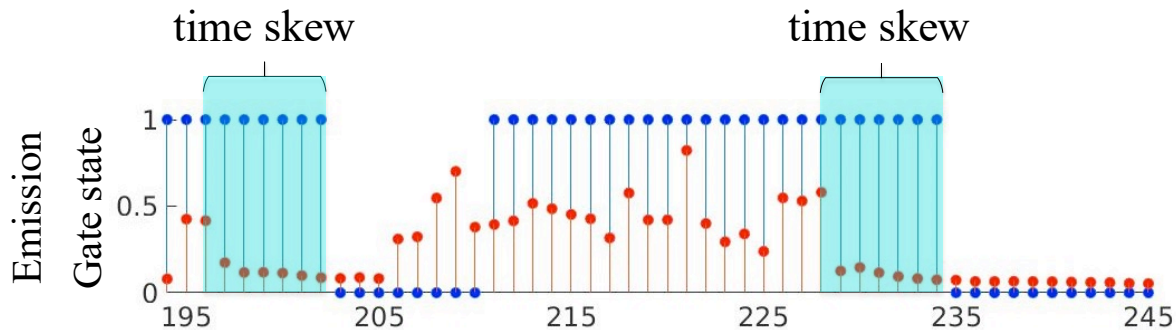
# Data Model



# Synchronization: Time Skew



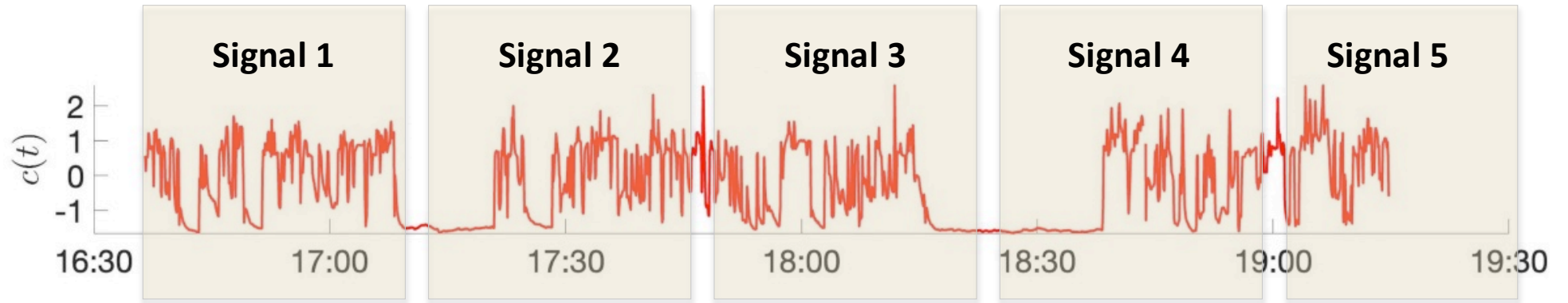
# Synchronization: Time Skew



# Synchronization: Alignment

1: Split the gas emission signal to the smaller sub-signals

Each sub-signal will be aligned independently



2: Time skew estimation

$$v[l] = \sum_{i=1}^m c[i]g[i+l]$$

Cross Correlation



$$\tau_* = \arg \max_l v(l)$$



$$\tau = t_{g_l} - t_{c_1}$$

Time Skew



$$\Delta T = 1 \dots 24 h$$



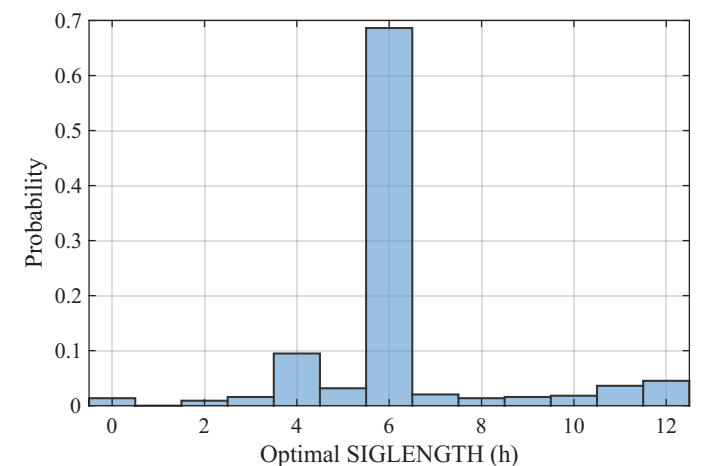
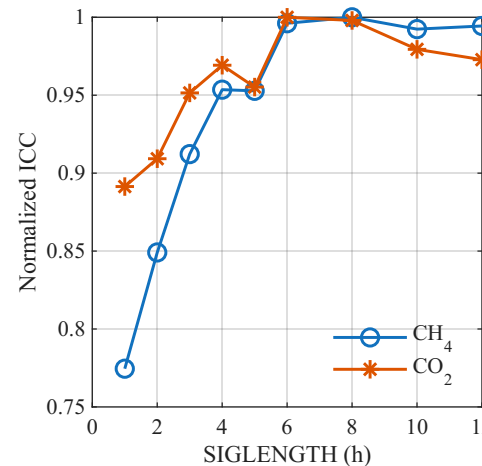
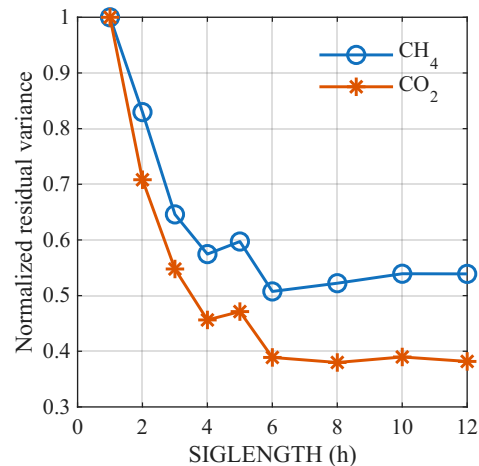
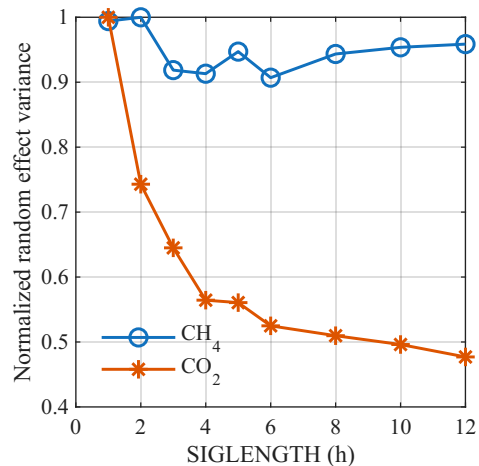
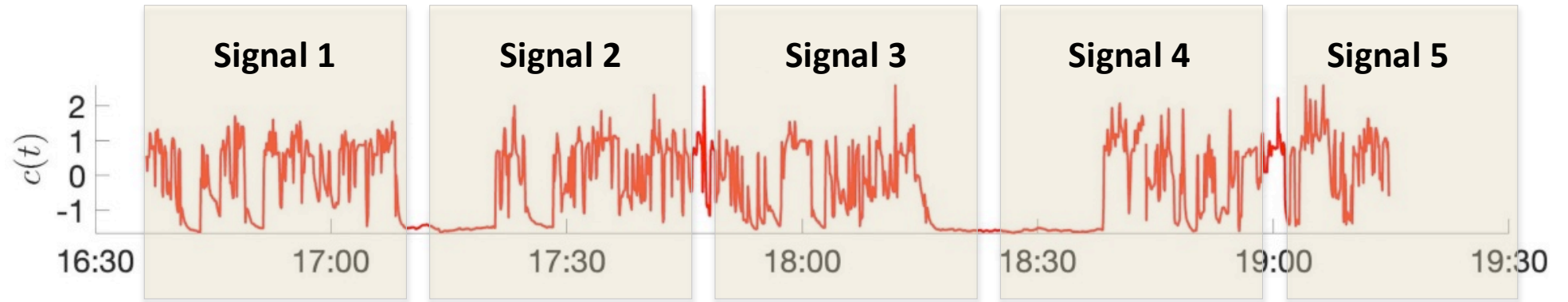
\$SIGLENGTH  
6

\$SIGLENGTH  
-6

# Synchronization: Alignment

## 1: Split the gas emission signal to the smaller sub-signals

Each sub-signal will be aligned independently

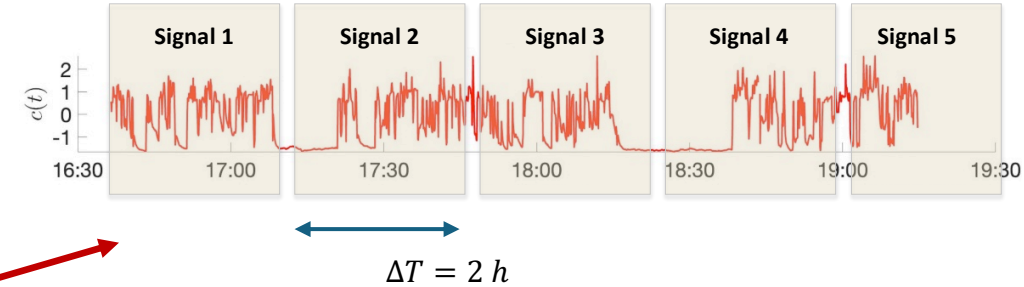


# Synchronization: Results

From the GEDA log file:

Results of alignment and reliability detection:

| Signal no. | Estimated skew, sec | Classif. as rlb. | Inferred skew, sec | Corected skew, sec | Used for phenotyping |
|------------|---------------------|------------------|--------------------|--------------------|----------------------|
| 1          | 36                  | true             | 36                 | 35                 | true                 |
| 2          | 35                  | true             | 35                 | 36                 | true                 |
| 3          | 36                  | true             | 36                 | 37                 | true                 |
| 4          | -469483             | false            | 40                 | 40                 | false                |
| 5          | 44                  | true             | 44                 | 42                 | true                 |
| 6          | 805766              | false            | 43                 | 42                 | false                |
| 7          | 99827               | false            | 40                 | 40                 | false                |
| 8          | -1786673            | false            | 36                 | 37                 | false                |
| 9          | 34                  | true             | 34                 | 36                 | true                 |
| 10         | 36                  | true             | 36                 | 35                 | true                 |
| 11         | 37                  | true             | 37                 | 35                 | true                 |
| 12         | 34                  | true             | 34                 | 35                 | true                 |
| 13         | 34                  | true             | 34                 | 34                 | true                 |
| 14         | 34                  | true             | 34                 | 34                 | true                 |
| 15         | -641900             | false            | 34                 | 34                 | false                |
| 16         | -1210841            | false            | 35                 | 35                 | false                |
| 17         | 466499              | false            | 37                 | 37                 | false                |
| 18         | 38                  | true             | 38                 | 38                 | true                 |
| 19         | 40                  | true             | 40                 | 40                 | true                 |
| 20         | 41                  | true             | 41                 | 41                 | true                 |
| 21         | 665988              | false            | 41                 | 41                 | false                |
| 22         | 40                  | true             | 40                 | 40                 | true                 |



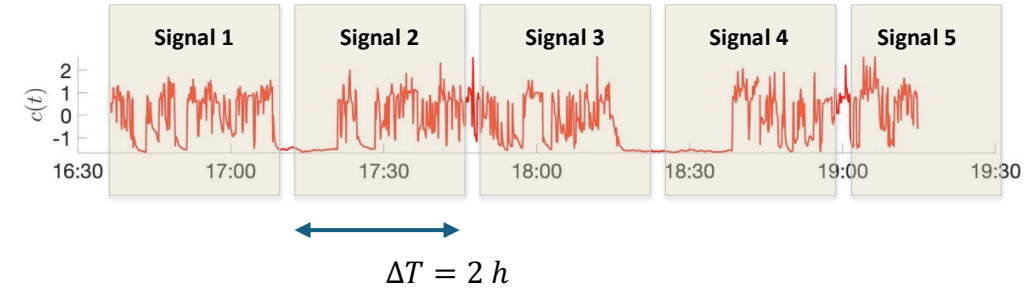
proportion of reliable data,                   %: 63.636  
 proportion used for phenotyping,           %: 63.636  
 elapsed time of MF detection,               sec: 0.597  
 elapsed time of reliability assessment, sec: 0.029

# Synchronization: Results

From the GEDA log file:

Results of alignment and reliability detection:

| Signal no. | Estimated skew, sec | Classif. as rlb. | Inferred skew, sec | Corrected skew, sec | Used for phenotyping |
|------------|---------------------|------------------|--------------------|---------------------|----------------------|
| 1          | 36                  | true             | 36                 | 35                  | true                 |
| 2          | 35                  | true             | 35                 | 36                  | true                 |
| 3          | 36                  | true             | 36                 | 37                  | true                 |
| 4          | -469483             | false            | 40                 | 40                  | false                |
| 5          | 44                  | true             | 44                 | 42                  | true                 |
| 6          | 805766              | false            | 43                 | 42                  | false                |
| 7          | 99827               | false            | 40                 | 40                  | false                |
| 8          | -1786673            | false            | 36                 | 37                  | false                |
| 9          | 34                  | true             | 34                 | 36                  | true                 |
| 10         | 36                  | true             | 36                 | 35                  | true                 |
| 11         | 37                  | true             | 37                 | 35                  | true                 |
| 12         | 34                  | true             | 34                 | 35                  | true                 |
| 13         | 34                  | true             | 34                 | 34                  | true                 |
| 14         | 34                  | true             | 34                 | 34                  | true                 |
| 15         | -641900             | false            | 34                 | 34                  | false                |
| 16         | -1210841            | false            | 35                 | 35                  | false                |
| 17         | 466499              | false            | 37                 | 37                  | false                |
| 18         | 38                  | true             | 38                 | 38                  | true                 |
| 19         | 40                  | true             | 40                 | 40                  | true                 |
| 20         | 41                  | true             | 41                 | 41                  | true                 |
| 21         | 665988              | false            | 41                 | 41                  | false                |
| 22         | 40                  | true             | 40                 | 40                  | true                 |



proportion of reliable data, %: 63.636

proportion used for phenotyping, %: 63.636

elapsed time of MF detection, sec: 0.597

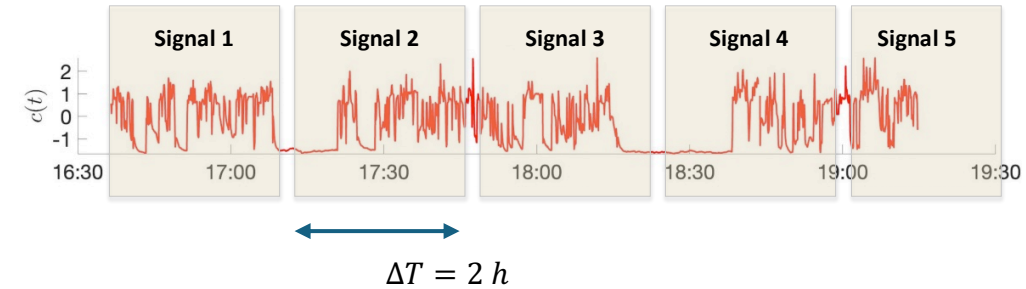
elapsed time of reliability assessment, sec: 0.029

# Synchronization: Results

From the GEDA log file:

Results of alignment and reliability detection:

| Signal no. | Estimated skew, sec | Classif. as rlb. | Inferred skew, sec | Corrected skew, sec | Used for phenotyping |
|------------|---------------------|------------------|--------------------|---------------------|----------------------|
| 1          | 36                  | true             | 36                 | 35                  | true                 |
| 2          | 35                  | true             | 35                 | 36                  | true                 |
| 3          | 36                  | true             | 36                 | 37                  | true                 |
| 4          | -469483             | false            | 40                 | 40                  | false                |
| 5          | 44                  | true             | 44                 | 42                  | true                 |
| 6          | 805766              | false            | 43                 | 42                  | false                |
| 7          | 99827               | false            | 40                 | 40                  | false                |
| 8          | -1786673            | false            | 36                 | 37                  | false                |
| 9          | 34                  | true             | 34                 | 36                  | true                 |
| 10         | 36                  | true             | 36                 | 35                  | true                 |
| 11         | 37                  | true             | 37                 | 35                  | true                 |
| 12         | 34                  | true             | 34                 | 35                  | true                 |
| 13         | 34                  | true             | 34                 | 34                  | true                 |
| 14         | 34                  | true             | 34                 | 34                  | true                 |
| 15         | -641900             | false            | 34                 | 34                  | false                |
| 16         | -1210841            | false            | 35                 | 35                  | false                |
| 17         | 466499              | false            | 37                 | 37                  | false                |
| 18         | 38                  | true             | 38                 | 38                  | true                 |
| 19         | 40                  | true             | 40                 | 40                  | true                 |
| 20         | 41                  | true             | 41                 | 41                  | true                 |
| 21         | 665988              | false            | 41                 | 41                  | false                |
| 22         | 40                  | true             | 40                 | 40                  | true                 |



proportion of reliable data, %: 63.636

proportion used for phenotyping, %: 63.636

elapsed time of MF detection, sec: 0.597

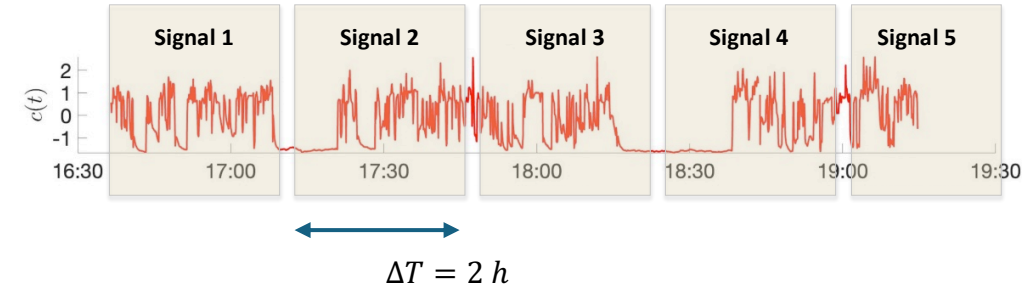
elapsed time of reliability assessment, sec: 0.029

# Synchronization: Results

From the GEDA log file:

Results of alignment and reliability detection:

| Signal no. | Estimated skew, sec | Classif. as rlb. | Inferred skew, sec | Corrected skew, sec | Used for phenotyping |
|------------|---------------------|------------------|--------------------|---------------------|----------------------|
| 1          | 36                  | true             | 36                 | 35                  | true                 |
| 2          | 35                  | true             | 35                 | 36                  | true                 |
| 3          | 36                  | true             | 36                 | 37                  | true                 |
| 4          | -469483             | false            | 40                 | 40                  | true                 |
| 5          | 44                  | true             | 44                 | 42                  | true                 |
| 6          | 805766              | false            | 43                 | 42                  | true                 |
| 7          | 99827               | false            | 40                 | 40                  | true                 |
| 8          | -1786673            | false            | 36                 | 37                  | true                 |
| 9          | 34                  | true             | 34                 | 36                  | true                 |
| 10         | 36                  | true             | 36                 | 35                  | true                 |
| 11         | 37                  | true             | 37                 | 35                  | true                 |
| 12         | 34                  | true             | 34                 | 35                  | true                 |
| 13         | 34                  | true             | 34                 | 34                  | true                 |
| 14         | 34                  | true             | 34                 | 34                  | true                 |
| 15         | -641900             | false            | 34                 | 34                  | true                 |
| 16         | -1210841            | false            | 35                 | 35                  | true                 |
| 17         | 466499              | false            | 37                 | 37                  | true                 |
| 18         | 38                  | true             | 38                 | 38                  | true                 |
| 19         | 40                  | true             | 40                 | 40                  | true                 |
| 20         | 41                  | true             | 41                 | 41                  | true                 |
| 21         | 665988              | false            | 41                 | 41                  | true                 |
| 22         | 40                  | true             | 40                 | 40                  | true                 |



proportion of reliable data, %: 63.636

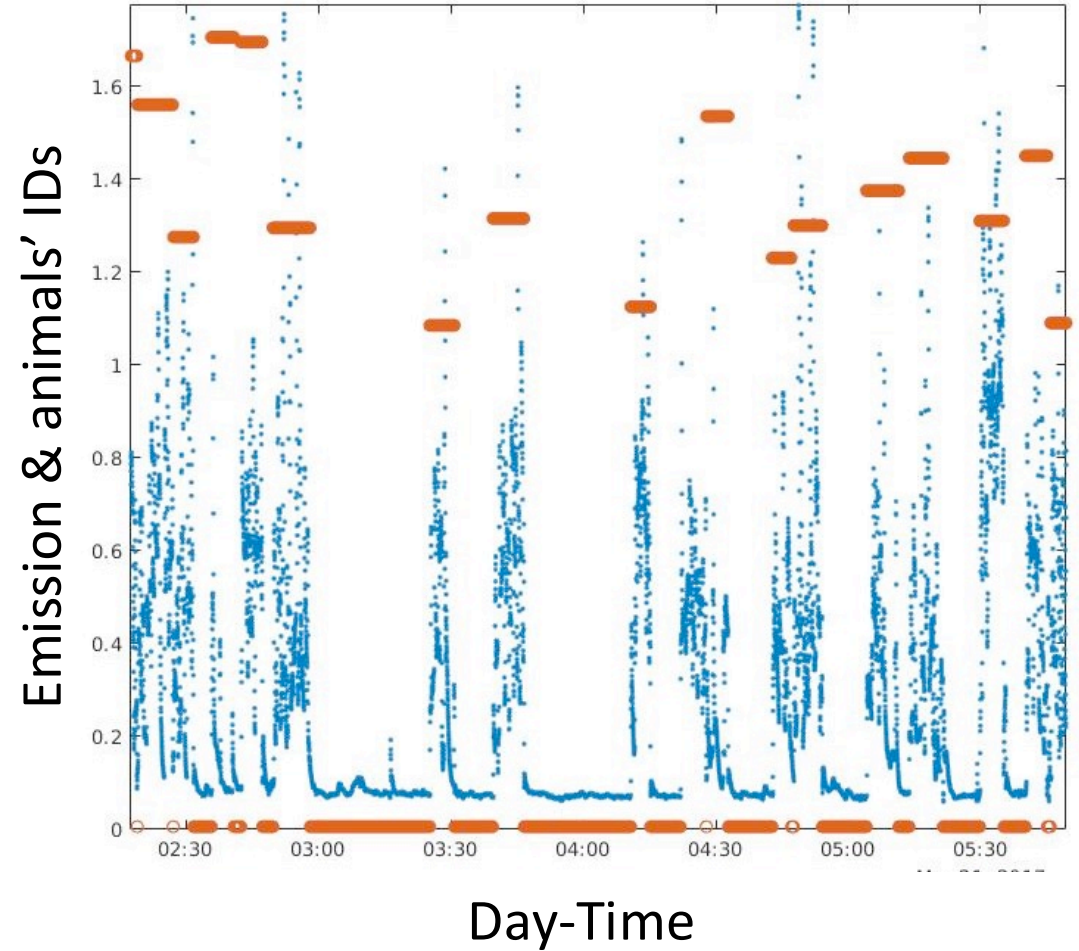
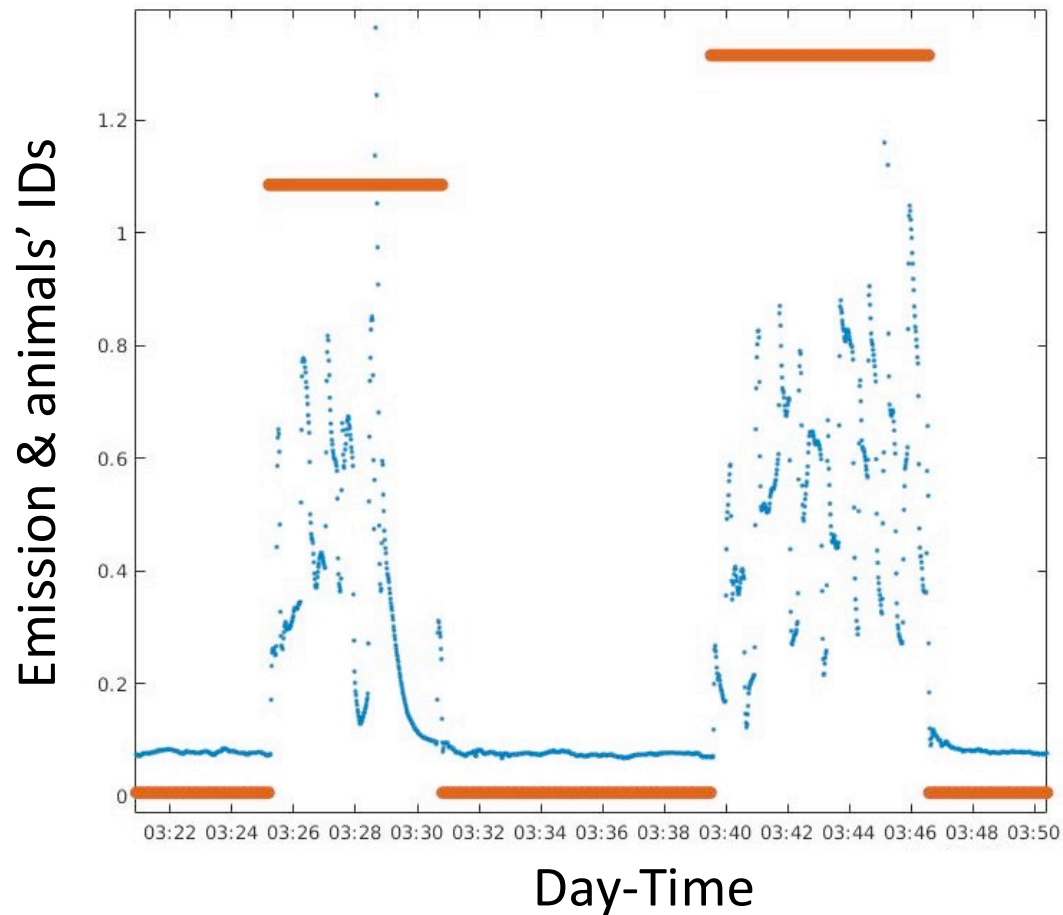
proportion used for phenotyping, %: 100.000

elapsed time of MF detection, sec: 0.607

elapsed time of reliability assessment, sec: 0.041

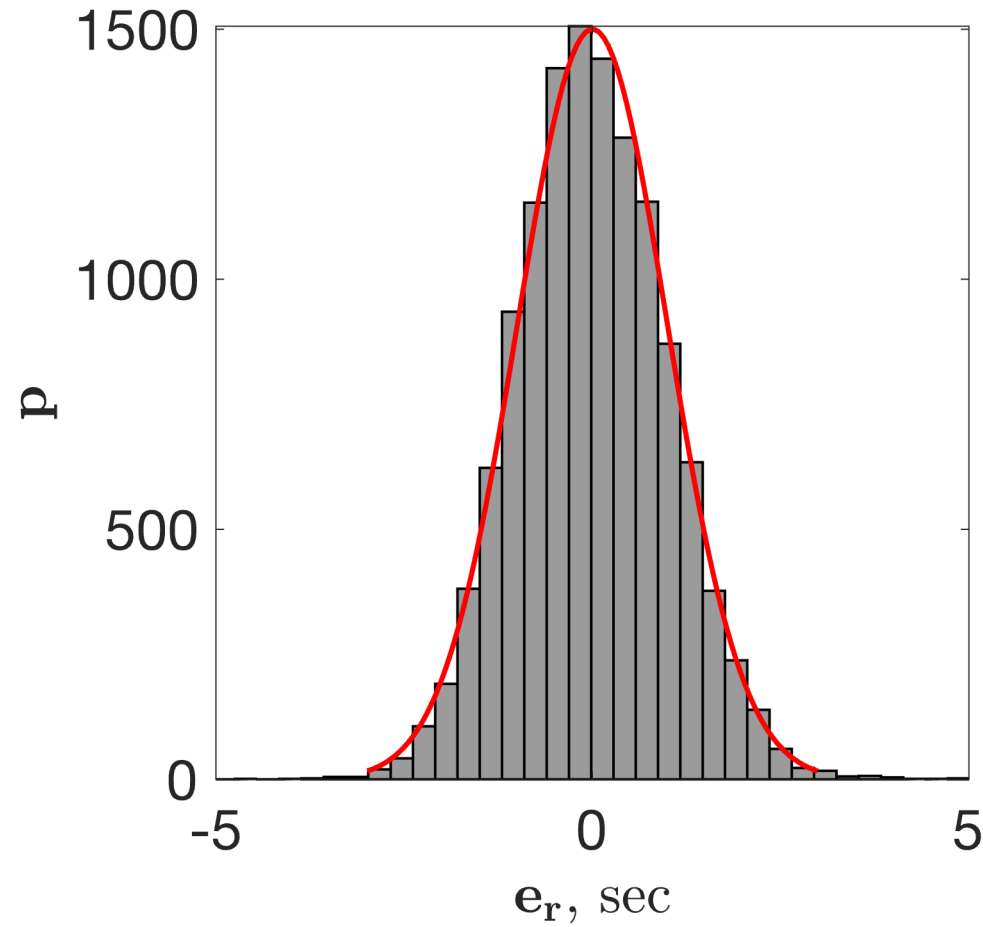
\$OPTIM  
o1

# Synchronization: Results



# Synchronization: Results

Synchronization error



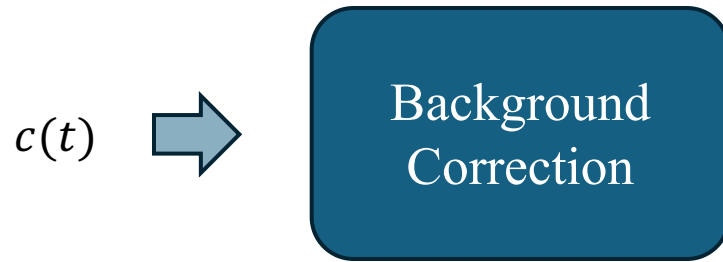
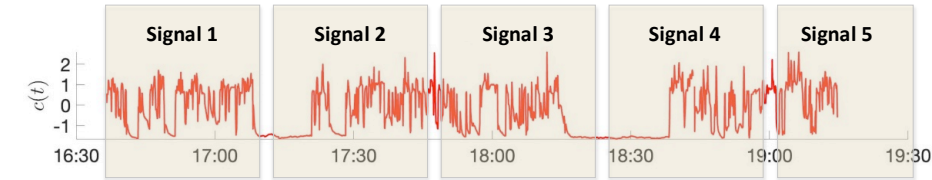
# Synchronization: Results

From the GEDA log file:

Off-visit and At-visit periods statistics of aligned signals:

| Signal no. | CH4 off-visit |          | CH4 at-visit |          | CO2 off-visit |          | CO2 at-visit |          |
|------------|---------------|----------|--------------|----------|---------------|----------|--------------|----------|
|            | mean          | rl.std,% | mean         | rl.std,% | mean          | rl.std,% | mean         | rl.std,% |
| 1          | 0.004         | 499.738  | 0.047        | 79.890   | 0.104         | 25.621   | 1.046        | 38.494   |
| 2          | -0.006        | -144.781 | 0.038        | 95.895   | 0.092         | 74.922   | 0.916        | 43.881   |
| 3          | -0.009        | -62.516  | 0.031        | 98.314   | 0.075         | 36.210   | 0.844        | 57.932   |
| 4          | -0.005        | -197.959 | 0.041        | 119.468  | 0.087         | 45.224   | 0.853        | 58.039   |
| 5          | -0.007        | -150.170 | 0.043        | 94.067   | 0.073         | 37.649   | 0.873        | 52.504   |
| 6          | -0.005        | -221.781 | 0.032        | 119.199  | 0.079         | 32.165   | 0.707        | 61.512   |
| 7          | 0.001         | 1562.713 | 0.035        | 115.961  | 0.095         | 35.410   | 0.814        | 53.057   |
| 8          | 0.021         | 102.584  | 0.046        | 93.810   | 0.123         | 45.175   | 0.880        | 50.038   |
| 9          | -0.008        | -70.482  | 0.030        | 143.253  | 0.082         | 27.555   | 0.749        | 57.878   |
| 10         | 0.001         | 1536.475 | 0.039        | 91.538   | 0.098         | 33.953   | 0.916        | 43.774   |
| 11         | -0.005        | -240.554 | 0.031        | 81.763   | 0.076         | 39.008   | 0.822        | 46.915   |
| 12         | -0.008        | -121.557 | 0.035        | 73.473   | 0.108         | 66.114   | 0.915        | 45.211   |
| 13         | -0.010        | -83.442  | 0.029        | 153.405  | 0.096         | 32.632   | 0.834        | 53.441   |
| 14         | -0.008        | -138.588 | 0.033        | 112.627  | 0.094         | 37.878   | 0.952        | 46.837   |
| 15         | 0.018         | 113.707  | 0.058        | 82.817   | 0.123         | 57.266   | 1.047        | 47.670   |
| 16         | -0.009        | -105.427 | 0.040        | 84.434   | 0.100         | 26.679   | 0.892        | 44.858   |
| 17         | -0.007        | -190.514 | 0.043        | 106.403  | 0.091         | 25.492   | 0.922        | 50.802   |
| 18         | 0.001         | 1325.312 | 0.046        | 75.690   | 0.139         | 47.742   | 0.968        | 45.306   |
| 19         | 0.007         | 256.764  | 0.050        | 86.128   | 0.120         | 52.602   | 1.065        | 45.625   |
| 20         | -0.006        | -254.806 | 0.042        | 73.563   | 0.150         | 59.506   | 0.965        | 40.857   |
| 21         | -0.005        | -268.018 | 0.037        | 105.714  | 0.212         | 68.230   | 0.879        | 47.162   |
| 22         | 0.002         | 1216.407 | 0.044        | 81.995   | 0.142         | 38.298   | 0.974        | 40.762   |

# Filtering Aligned Signals



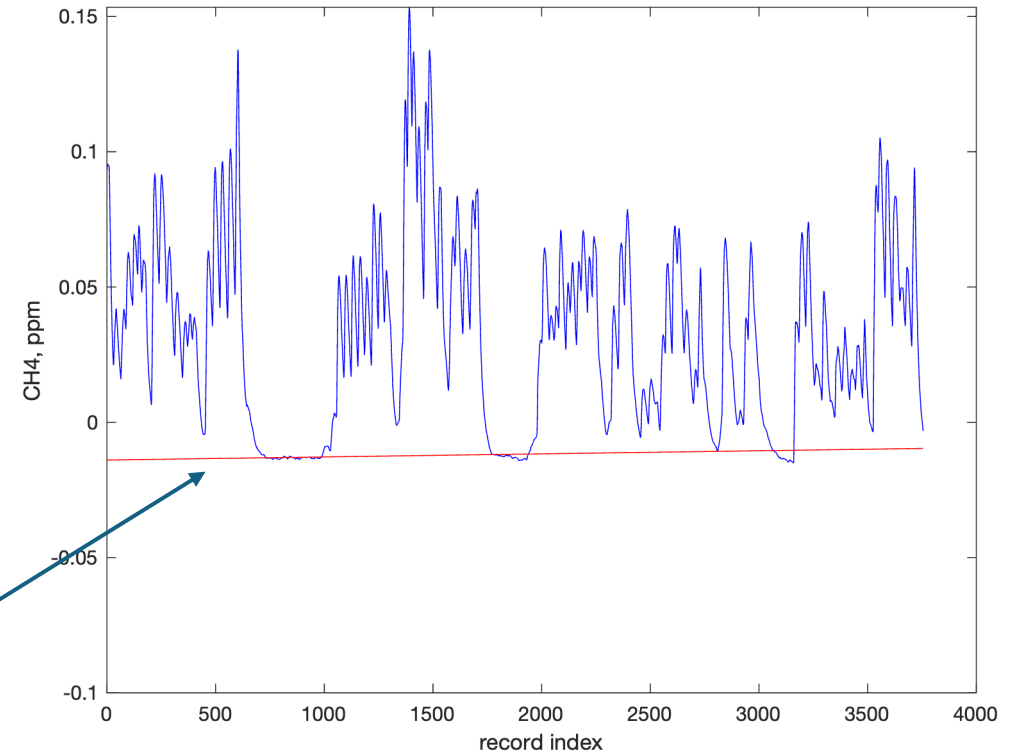
**Weighted linear regression**

$$c_{\text{bkg}} \sim a_0 + a_1 t + a_2 t^2 + e$$

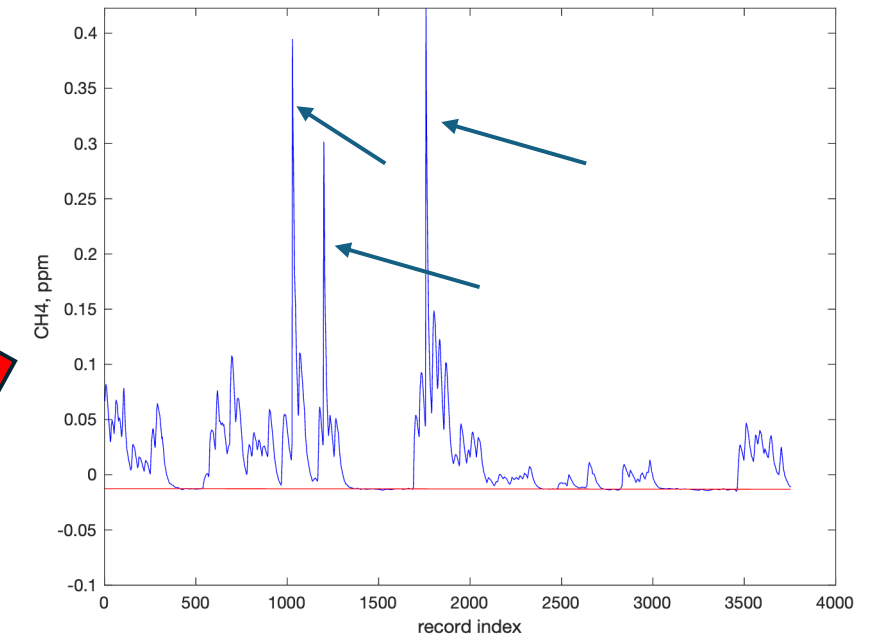
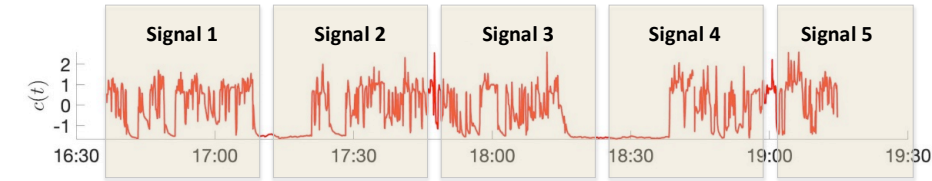
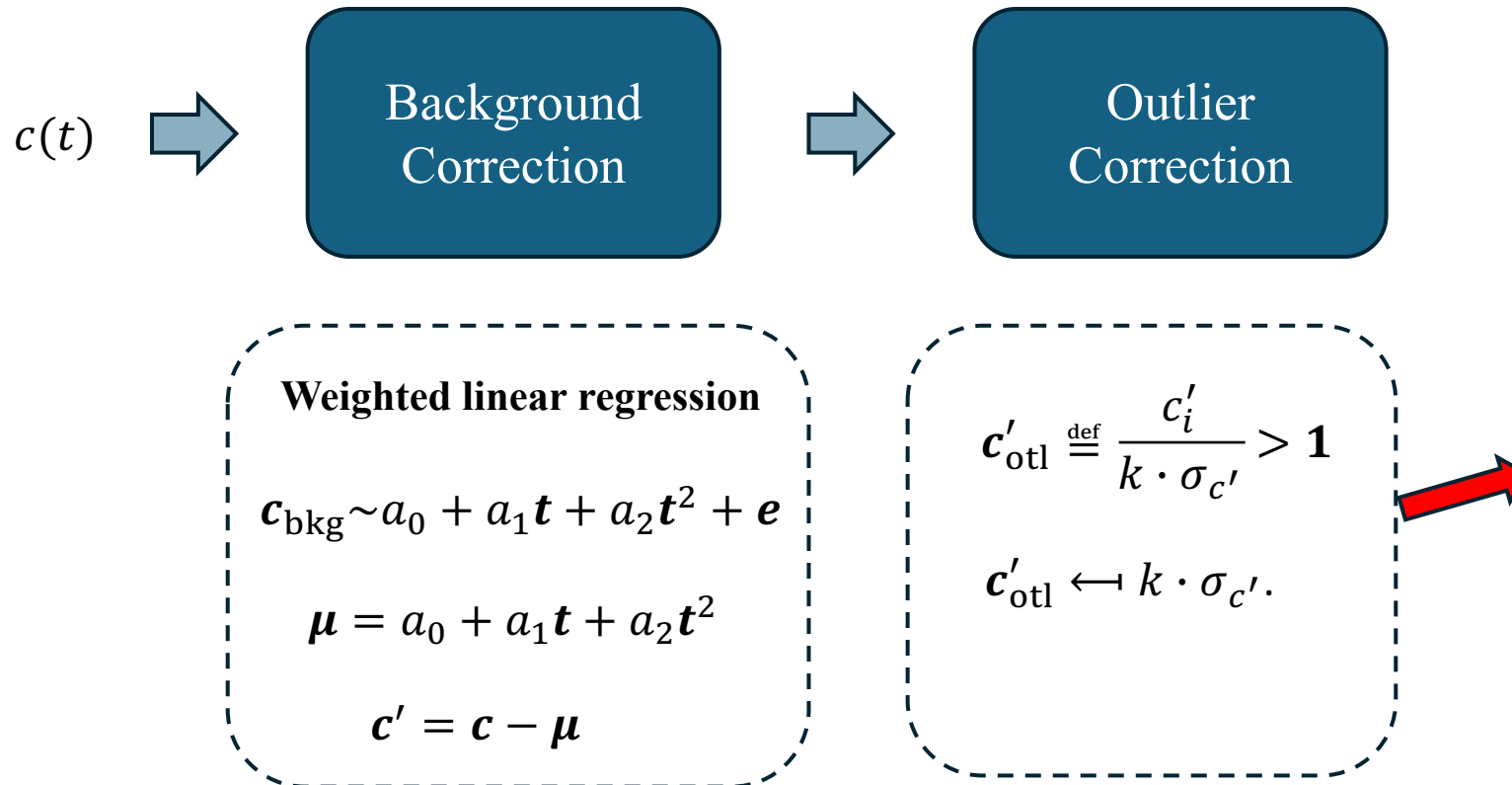
$$\mu = a_0 + a_1 t + a_2 t^2$$

$$c' = c - \mu$$

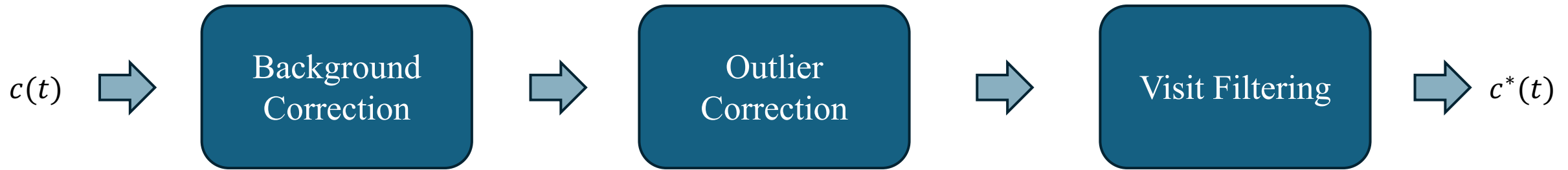
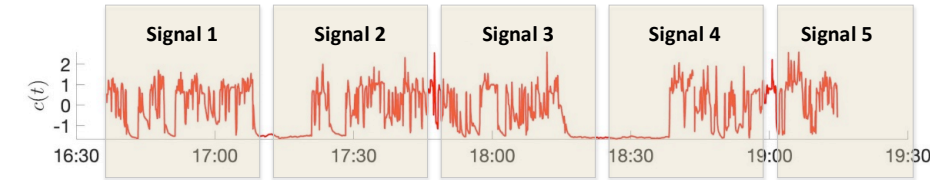
- bkgCH4
- bkgCO2



# Filtering Aligned Signals



# Filtering Aligned Signals



**Weighted linear regression**

$$c_{\text{bkg}} \sim a_0 + a_1 t + a_2 t^2 + e$$

$$\mu = a_0 + a_1 t + a_2 t^2$$

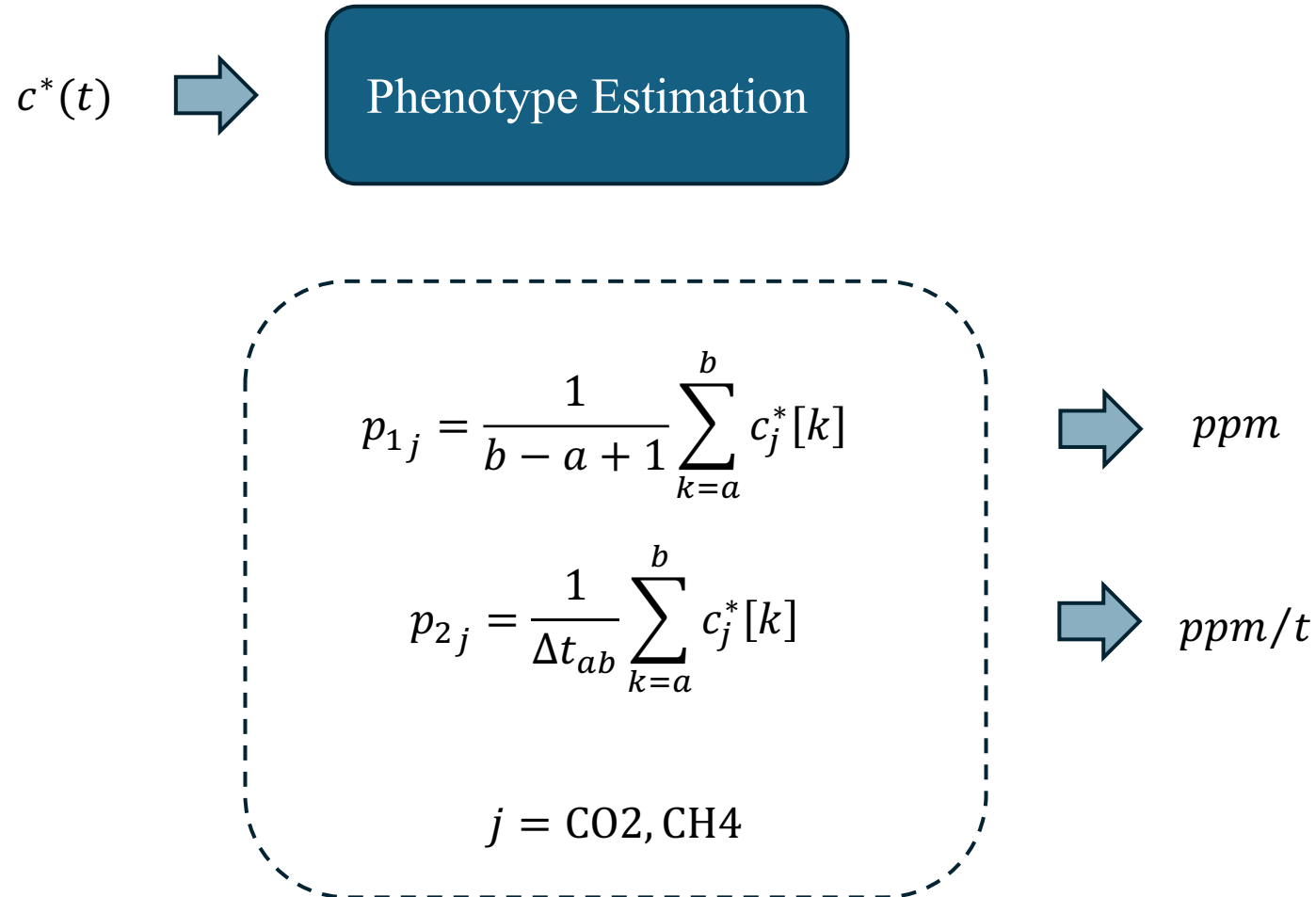
$$c' = c - \mu$$

$$c'_{\text{otl}} \stackrel{\text{def}}{=} \frac{c'_i}{k \cdot \sigma_{c'}} > 1$$

$$c'_{\text{otl}} \leftrightarrow k \cdot \sigma_{c'}$$

- Minimum Visit Duration
- Visit Edges Trimming
- Minimum Emission Threshold

# Phenotypes Estimation

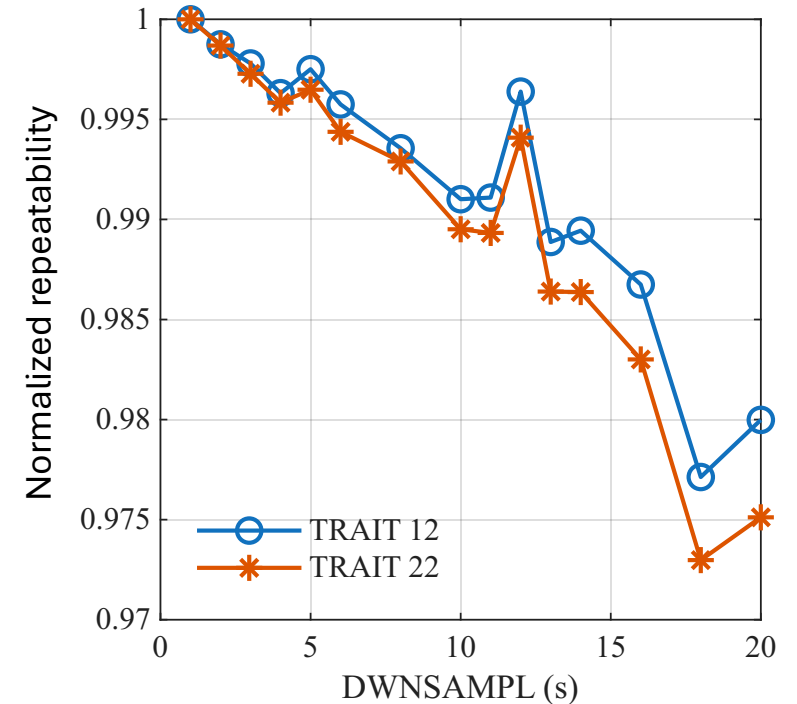
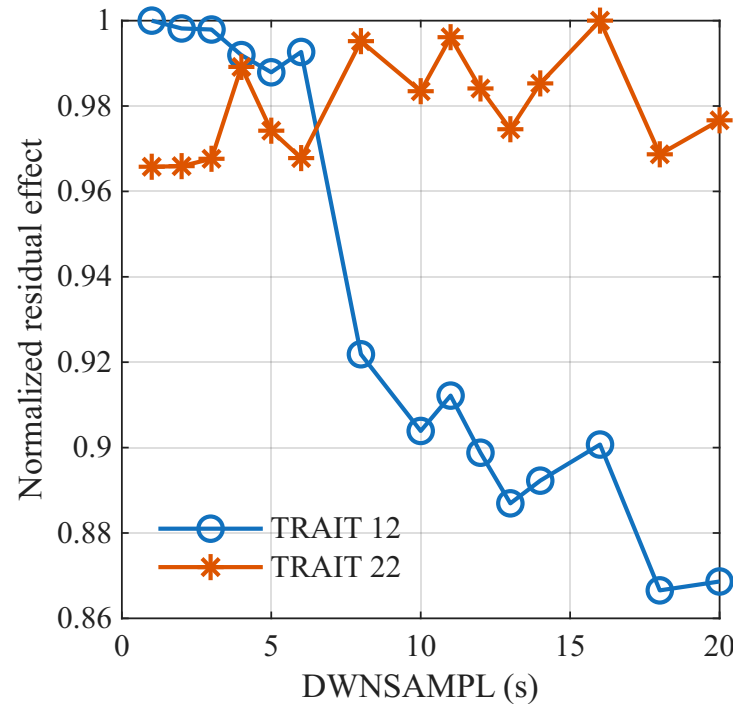
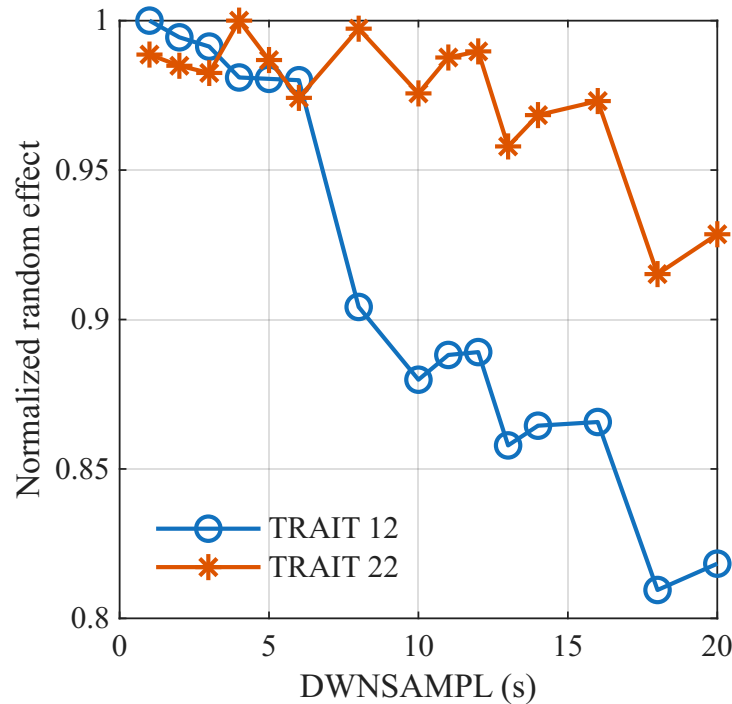


# Phenotypes Estimation

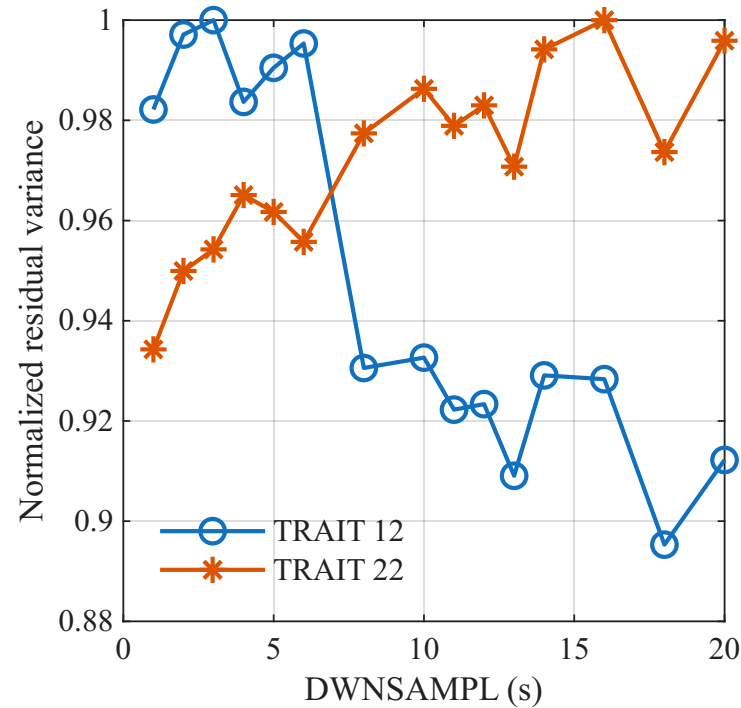
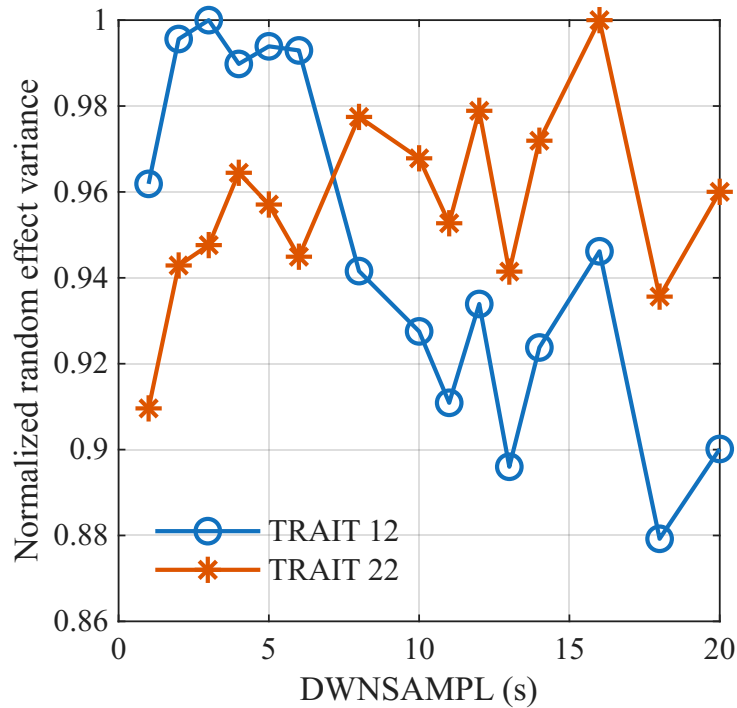


## CH4

TRAIT 12 => ppm  
 TRAIT 22 => ppm/min

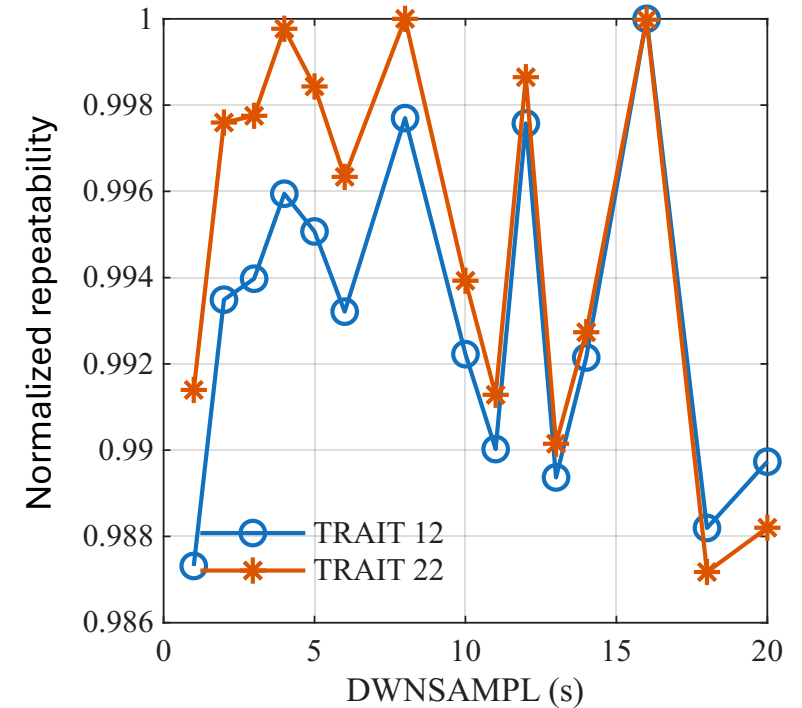


# Phenotypes Estimation



## CO2

TRAIT 12 => ppm  
TRAIT 22 => ppm/min



# Processed Data Quality Estimation



Linear mixed model:

$$\mathbf{p} = \boldsymbol{\theta} + \mathbf{X}\mathbf{b} + \mathbf{Z}\mathbf{a} + \mathbf{e}$$

Intraclass correlation coefficient  
(local quality metric)

$$r = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

From the GEDA log file:

```
CH4 model: CH4 ~ 1 + Date + bkgCH4 + hour + (1|CowID)
num. observations per ID:          3.018
fit quality, adjusted r^2:        0.57438
random effect variance (var_id):  0.00019982
residual variance (var_err):      0.00018711
var_id/(var_id+var_err):          0.51642
```

# Processed Data Quality Estimation



Linear mixed model:

$$\mathbf{p} = \boldsymbol{\theta} + \mathbf{X}\mathbf{b} + \mathbf{Z}\mathbf{a} + \mathbf{e}$$

Intraclass correlation coefficient  
(local quality metric)

$$r = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_e^2}$$

**From the GEDA log file:**

```

C02 model: C02 ~ 1 + Date + bkgC02 + hour + (1|CowID)
num. observations per ID:          3.018
fit quality, adjusted r^2:        0.70289
random effect variance (var_id):  0.030822
residual variance (var_err):      0.016298
var_id/(var_id+var_err):          0.65412
  
```

# Some Results

GENERAL MODEL

$$y = X\beta + Z_a a + Z_{pe} pe + \varepsilon$$

$y$  : methane (CH<sub>4</sub>)

$X\beta$ : fixed effects

$a$ : additive genetic effect

$pe$ : permanent environment

$e$ : residual

**Model 1**  $y = \text{Parity} + \text{HYMSA} + \text{DIM} + \text{DMI}^2 + \text{wilmink} + a + pe + \varepsilon$

**Model 2**  $y = \text{Parity} + \text{HYMSA} + \text{DIM} + \text{DMI}^2 + \text{wilmink} + \text{backCH}_4 + a + pe + \varepsilon$

**Model 3**  $y = \text{Parity} + \text{HYMSA} + \text{DIM} + \text{DMI}^2 + \text{wilmink} + \text{backCH}_4(\text{HYMSA}) + a + pe + \varepsilon$

**Model 4**  $y = \text{Parity} + \text{HYMSA} + \text{DIM}(\text{hp}) + \text{DMI}^2(\text{hp}) + \text{wilmink}(\text{hp}) + \text{backCH}_4(\text{HYMSA}) + a + pe + \varepsilon$

Definition of terms      HYMSA= Herd\*Year\*Month\*Sniffer\*AMS  
    hp= Herd\*Partiy

# Some Results

Year : 2022-2026

Farms: 42

Number of unique cows: 17771

Total observations: 2599735

Observations per cow:

Mean: 146.29

Median: 102

Min: 1

Max: 1080

| Model | $\sigma^2_g$ (SE)   | $\sigma^2_{pe}$ (SE) | $\sigma^2_e$ (SE)  | $h^2$        | r            | -2logL            |
|-------|---------------------|----------------------|--------------------|--------------|--------------|-------------------|
| 1     | 4325.51<br>(509.62) | 6170.82<br>(389.26)  | 22341.2<br>(49.16) | <b>0.132</b> | <b>0.320</b> | <b>4.6069E+06</b> |
| 2     | 4301.79<br>(508.64) | 6185.81<br>(389.11)  | 22239.0<br>(48.94) | <b>0.132</b> | <b>0.320</b> | <b>4.6050E+06</b> |
| 3     | 4166.04<br>(501.99) | 6266.89<br>(387.56)  | 21681.1<br>(47.74) | <b>0.130</b> | <b>0.325</b> | <b>4.5866E+06</b> |
| 4     | 3906.17<br>(480.54) | 6202.89<br>(375.44)  | 21570.6<br>(47.50) | <b>0.123</b> | <b>0.319</b> | <b>4.5847E+06</b> |

# Summary

❑ **GEDA** allows an automated processing a sniffers data.

❑ The program provides:

- Initial quality control and filtering.
- Data alignment.
- Detection and filtering off an unreliable data.
- Phenotypes estimation.
- Quality assessment of estimated phenotypes.
- Comprehensive reporting.

ICAR 2026

Thursday – 4 June 2026

(8.30-10.30)

Technical Session 2

❑ Other GEDA related products are dedicated for production systems.

❑ They provide:

- Automated GEDA launches on entire data storage. (**GEDA Server**)
- Continuous phenotype integration. (**GEDA Server**)
- Postprocessing filtering. (**GEDA Server**)
- Production log and summary. (**GEDA Server**)
- Database integration. (**GEDA DB**)