

A decorative graphic consisting of several overlapping, semi-transparent shapes in shades of brown, tan, and white, resembling a stylized leaf or a cluster of petals.

Indoor climate & pig health

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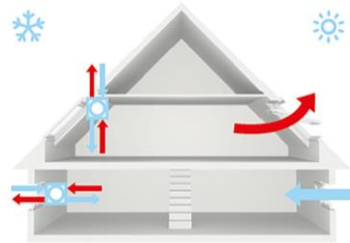
- Indoor climate parameters and impact on pig health
- Use of sensor data
- Results
- Concluding comments



Simplified climate control in winter and summer

Winter

- Stable temperature within target values
- Enough fresh air and CO₂ and NH₃ concentration below target values
- Stable relative humidity within target values

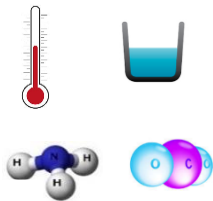


Summer

- Prevention of high indoor temperature
- Stable relative humidity within target values

Parameters for real time monitoring

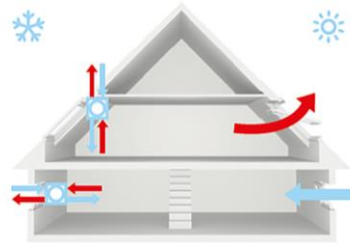
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- Concentration CO₂
- Concentration NH₃



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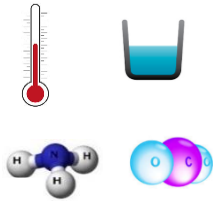


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Climate management instruments

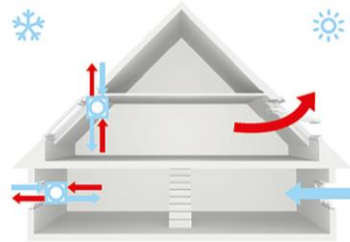
- Barn dimensions (m³/animal)
- Building material
- Feeding system
- Climate computer (type, settings, ventilation)



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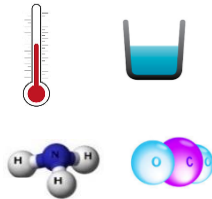


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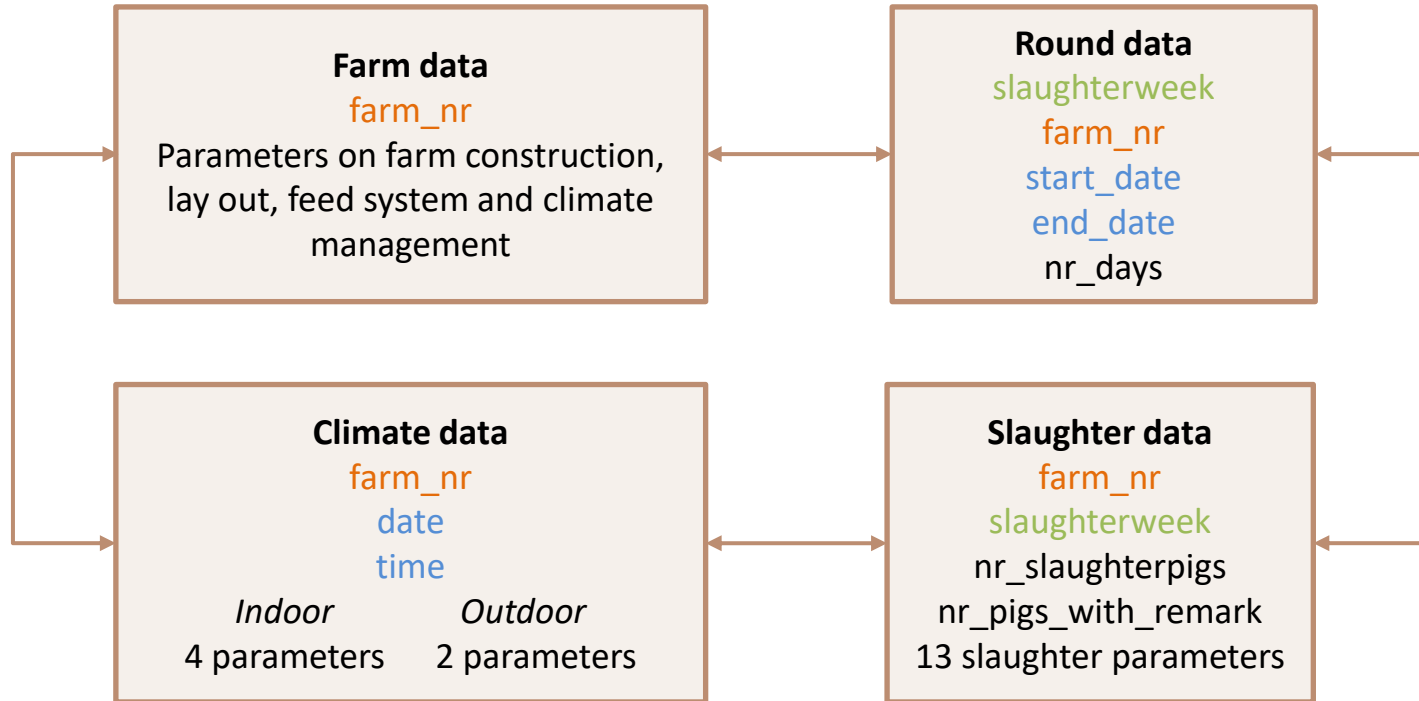
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Effects on health and welfare *(and economics)*

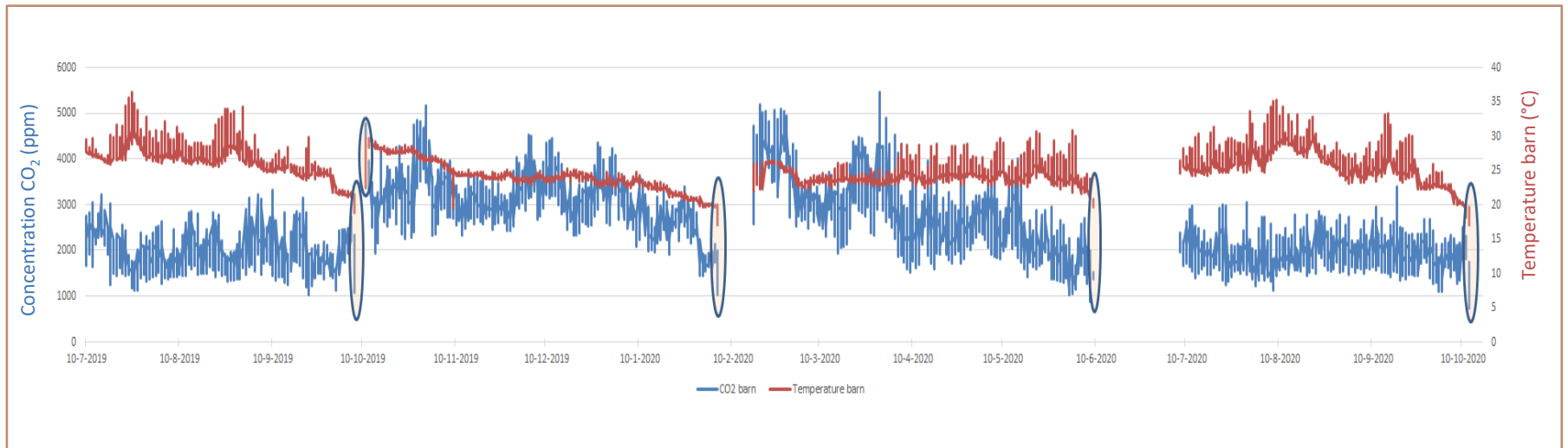
- Farm level: growth, behaviour, feed intake and feed conversion
- Slaughter level: lesions and abnormalities on pig carcasses (lung, pleura, pericardium, tail)





Cleaning real time data

- Identifying units of observation (in this case: one round is one observation)
- Deleting outliers (e.g. sensor malfunctioning, compartment empty)



Each sensor parameter (T, RH, CO₂, NH₃) produces 14.000 to 16.000 datapoints per round (one value per ten minutes)

Features are useful for analysis and testing the explanatory power for the relationship with animal health parameters.

Features we use are e.g.:

- Mean, standard deviation, maximum and minimum values per round
- Average daily range (maximum - minimum)
- Average daily maximum and minimum
- Q_{2_5}, Q₂₅, Q₅₀, Q₇₅, Q_{97_5}
- Q3-Q1 range (50% of values without lowest 25% and highest 25%)
- Percentage of values under, in and above targets per day and per round
- Percentage values high for 3 consecutive hours
- Number of days under, in and above targets

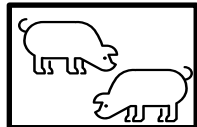
Descriptive statistics



21 farmers



1,958 ppm CO₂
3,737 ppm CO₂ maximum



270 pigs per compartment
2.6 m³ per pig



19.7 ppm NH₃



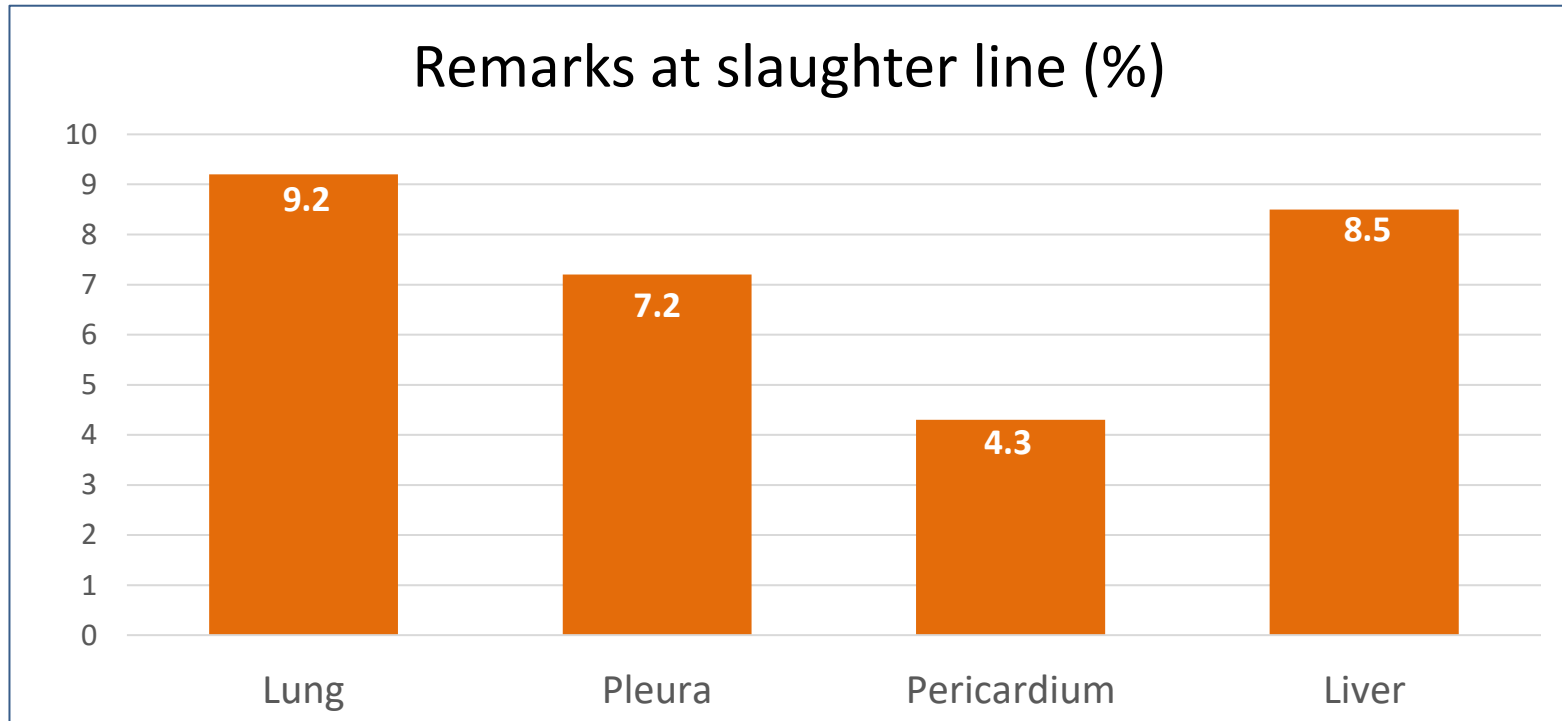
100 fattening rounds



> 5,760,000 sensor measurements



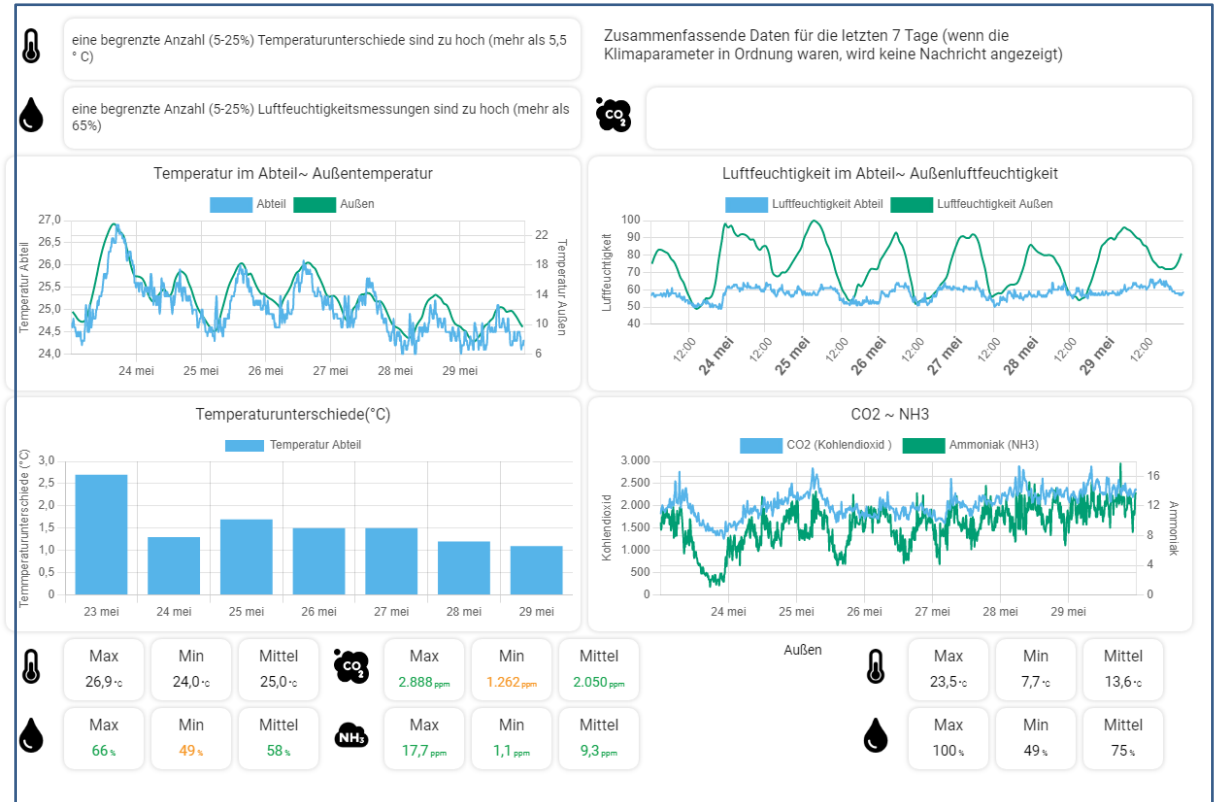
66 % humidity
3.4% observations with humidity >70%



Data representations

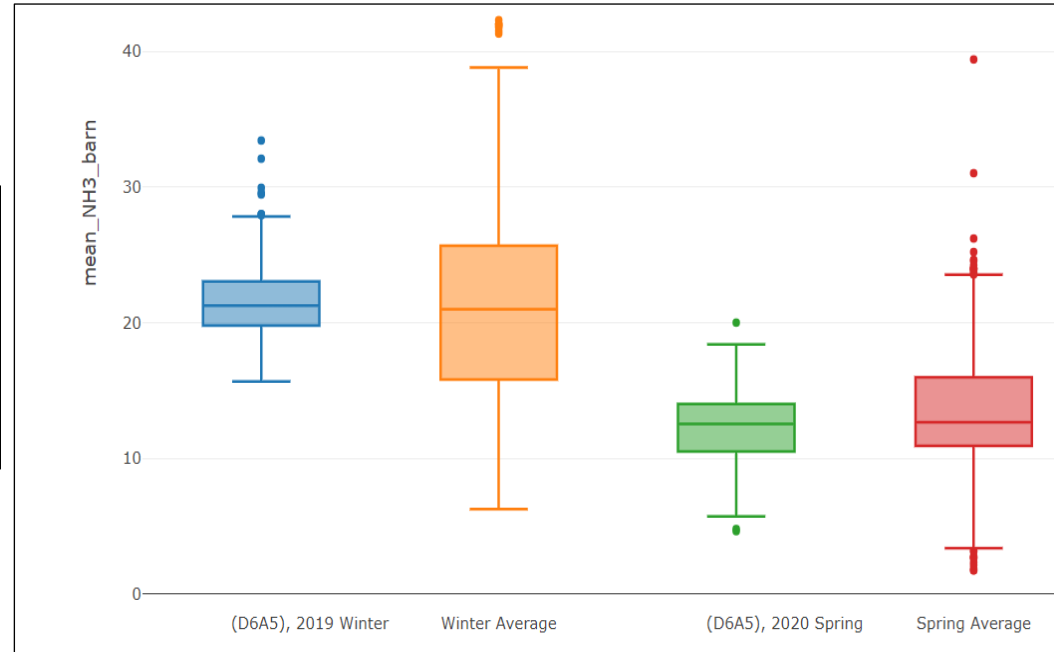
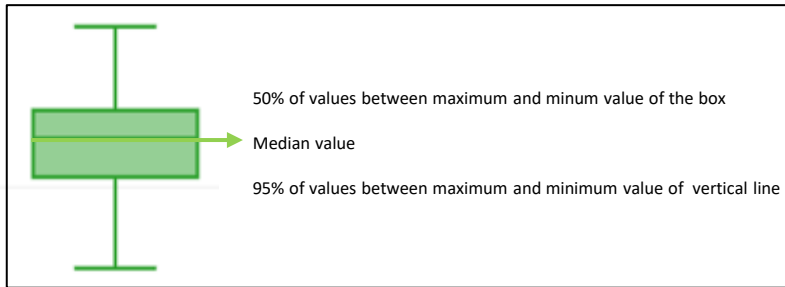
Weekly reports

- Each Monday morning
- Graphs (T, RH, CO₂ NH₃)
- Summary statistics
- Linguistic summaries



Data representations

Boxplot benchmark per round and by season

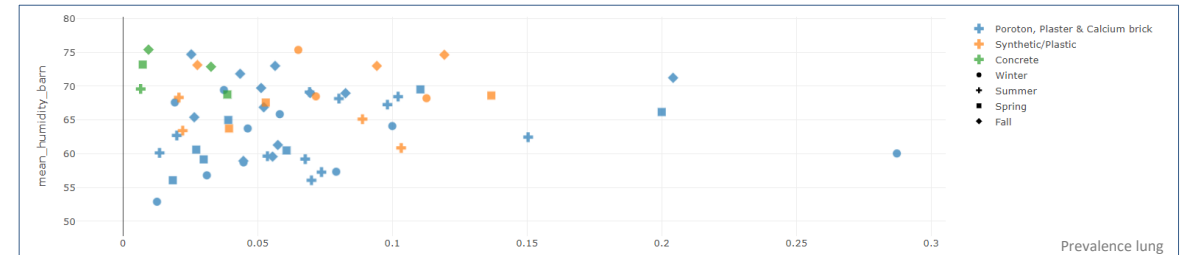
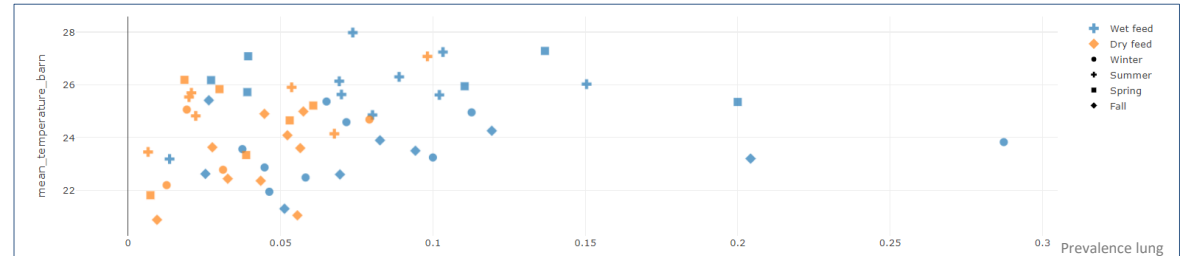
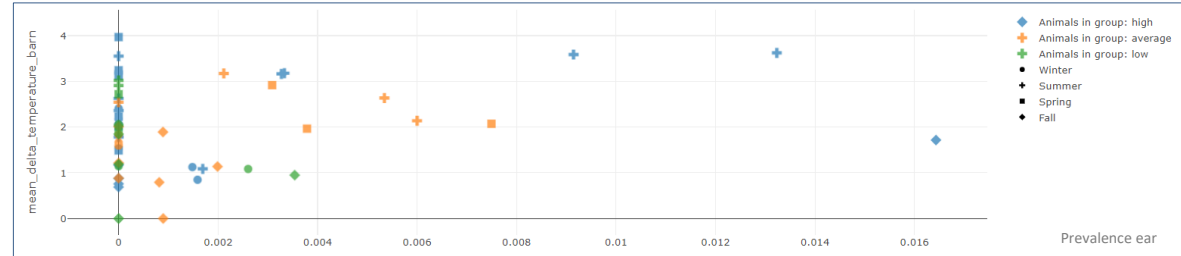


Data representations

Scatter plot slaughter parameters for all rounds

- Season
- Farm characteristic
 - Animals in group (high, average, low)
 - Feed system (wet, dry)
 - Building material (concrete, synthetic, plaster)

Scatter plots are helpful in analyzing the more extreme values in the spectrum



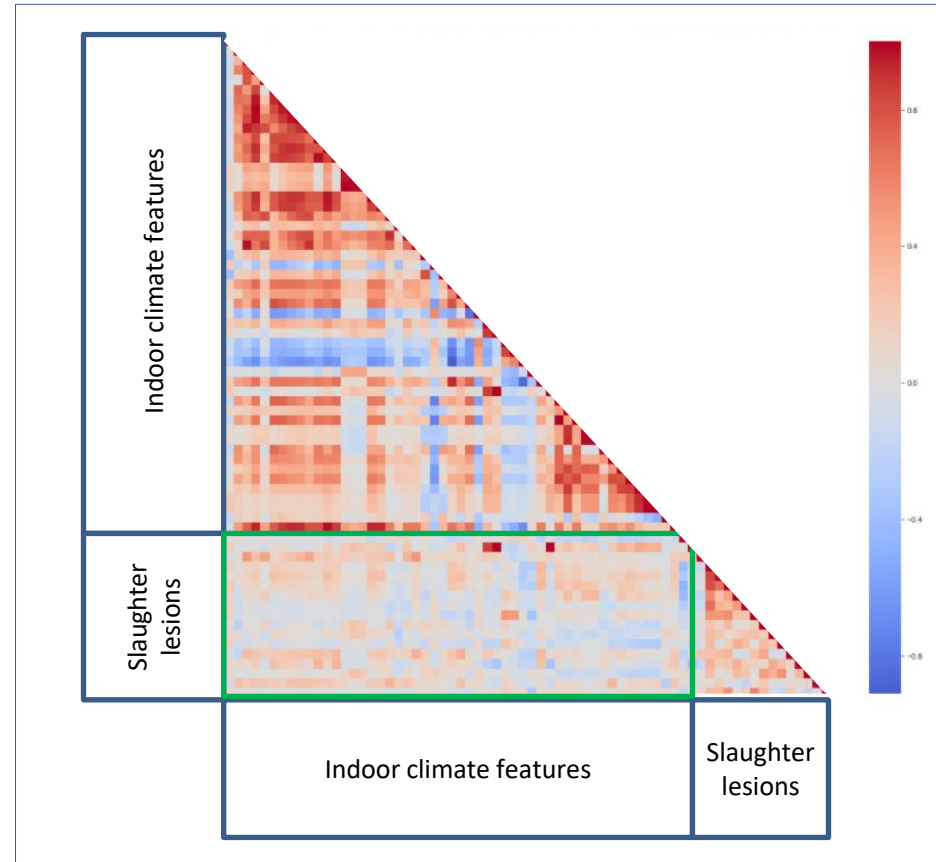
Correlations Features climate & lesions

Correlations for indoor climate features with 14 lesions at slaughter.

Features with correlation > 0.20 or < -0.20 with lesions include

- Temperature: daily change (avg. of maximum – minimum)
- CO₂: sensor values on daily max. and bandwidth Q3 - Q1
- Humidity: sensor values on humidity $< 30\%$ and $> 70\%$
- NH₃: % sensor values > 20 ppm and daily change

Variation in mean barn temperature strongly related ($R^2 = 0.80$) with major climate features for humidity, CO₂ and NH₃.



Strength of relationships



0.00 < p < 0.05: +++ Very strong relationship

0.06 < p ≤ 0.10: ++ Strong relationship

0.11 < p ≤ 0.20: + Weak relationship

All major slaughter remarks are related to more than one indoor climate feature and barn characteristic

Significance level	% Lung	% Pleura	% Bowel	% Ear	% Skin Lesion
R ² adjusted	0.237	0.243	0.411	0.218	0.272
Humidity (% too low)			+++	+	++
Humidity (% too high)		+			
Delta temp. too high	+++	+			+++
Delta temp. extr. High	++				+
CO ₂ Q3-Q1 range		+			+++
NH ₃ above 20 ppm over one hour			+	+++	
Average daily change in NH ₃	+++	+++	++	+++	++
% NH ₃ above 20 ppm 1 st part round	+	++			
Cubic meters per animal	+++	+++	+++	+++	+++

Expected impact climate features



Impact indoor climate features and barn characteristics on expected change in health parameters

Feature	From	To	Lung from 9.2% to ..	Pleura from 7.2% to ..
% Humidity values too high	34	44		7.7
% Temperature changes too high	4	8	11	8.2
% Temperature changes extremely high	0.2	0.3	9.4	
Average daily bandwidth CO ₂ values (Q3-Q1)	650	800		7.7
Average hourly change in NH ₃ values	1.5	1.6	8.5	6.8
Hours NH ₃ values >20 ppm in 1 st part round	500	750	11.7	9.7
Cubic meters per animal	2.6	3.0	7.4	5.0

Most relationships are as expected, except for the average hourly change in NH₃ values. Please note that according to the technical specifications of the sensor a difference of 0.1 ppm NH₃ is within the margin of error.

Major findings

- Great variation in indoor climate between farms indicates that substantial improvements can be made
- Indoor climate conditions have a significant relationship with animal health parameters

Reflection

- Data cleaning crucial element of analyzing big data
- Variation in management and barn characteristics: significance does not imply causations
- Next step: integrated indoor climate index combining T, RH, CO₂ and NH₃

