Facilitating decision-making using data collected with PLF technologies and ML algorithms to predict shade-seeking behaviour in dairy heifers

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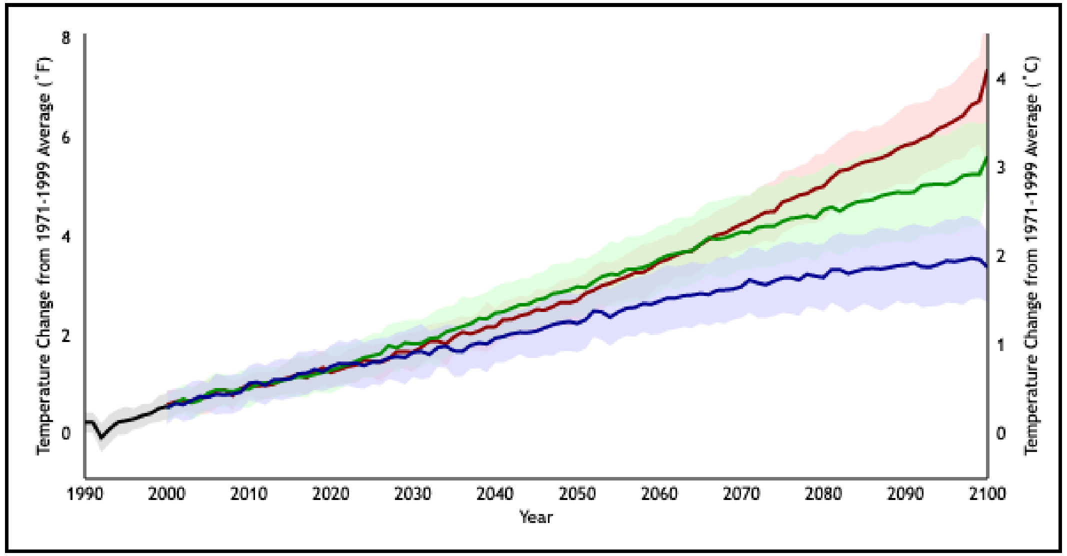
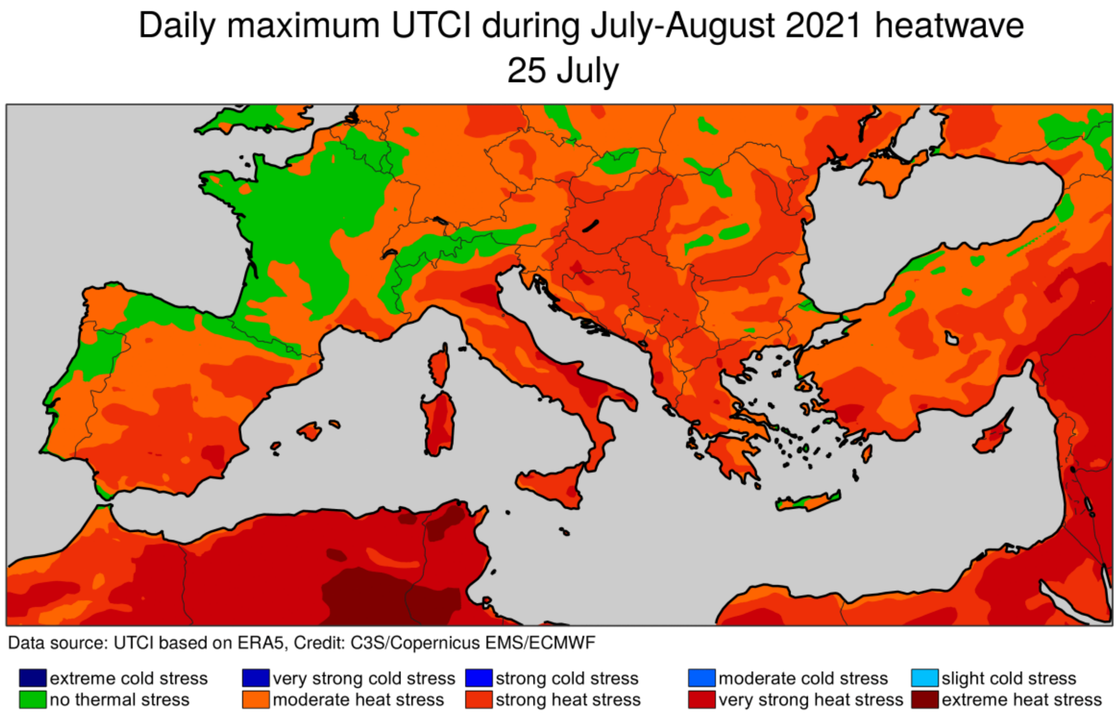
Climate change as a key burden for sustainable animal production



Source: www.climate.gov

Innovative approaches are needed to tackle heat stress



Copernicus Climate Change Service
European State of the Climate | 2021
PROGRAMME OF THE EUROPEAN UNION
Copernicus Europe's eyes on Earth
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Adapted and context-specific solutions are needed

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Offering solutions towards more sustainable animal production

Improve animal welfare

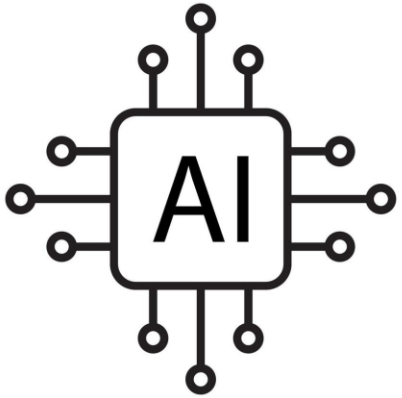
Increase production efficiency

Source: © Nesterenkoruslan

Reduce negative environmental impacts

Reduce workload and improve quality of life

Facilitating decision-making

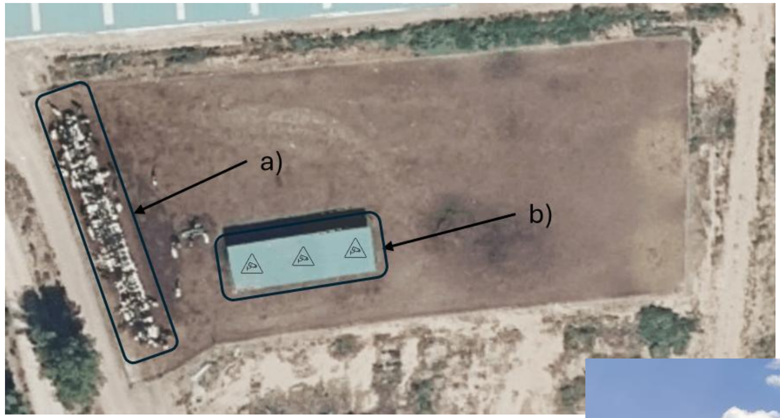


Aim

Create added value to data collected through precision livestock farming (PLF) technologies by predicting shade-seeking behaviour in dairy heifers

Materials and Methods

- **Farm description**
  - Contract-rearing Holstein farm located in Valencia (830m above sea level)
  - >3000 animals present on the farm
  - 250m^2 feedlot selected for the experiment
    - Animals between 6-7 months
    - Animals are fed daily at 10:00am



- **Computer vision set-up**
  - 3 cameras covering the artificial shade
    - Counting of animals below the shade
  - Sensors to measure climatic conditions
    - Temperature
    - Relative humidity

Materials and Methods

Per Time Point During the Daytime Period (07:00–21:00):

1. THI value at the given time *t*.
2. Mean THI from the previous night (21:00–07:00)
3. Mean THI from 07:00 to the current time *t*

Temporal Features from Previous *n* Days (n = 1 to 10):

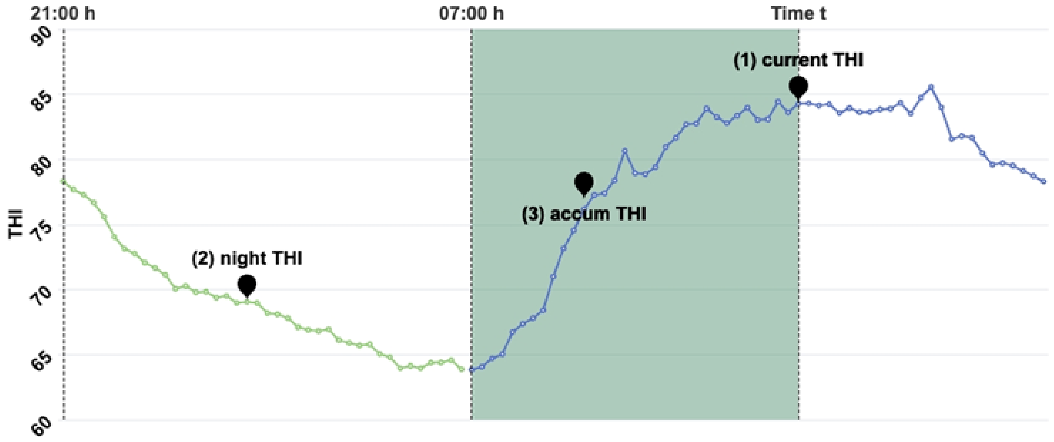
4. Average THI over the full day.
5. Average THI during the daytime (07:00–21:00)
6. Average THI during nighttime (21:00–07:00)

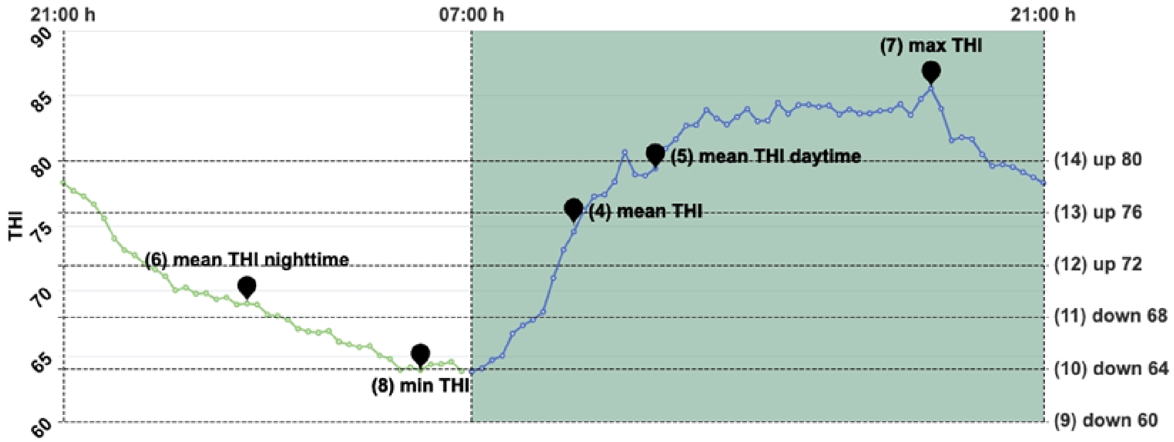
Extreme Environmental Conditions:

7. Maximum THI value over the previous *n* days
8. Minimum THI value over the previous *n* days

Duration of Heat Stress (per *n*-day period):

9. Number of hours with THI < 60 // 64 // 68
10. Number of hours with THI > 72 // 76 //80





Selecting the best approach for animal prediction

Random Forest

Appr 1

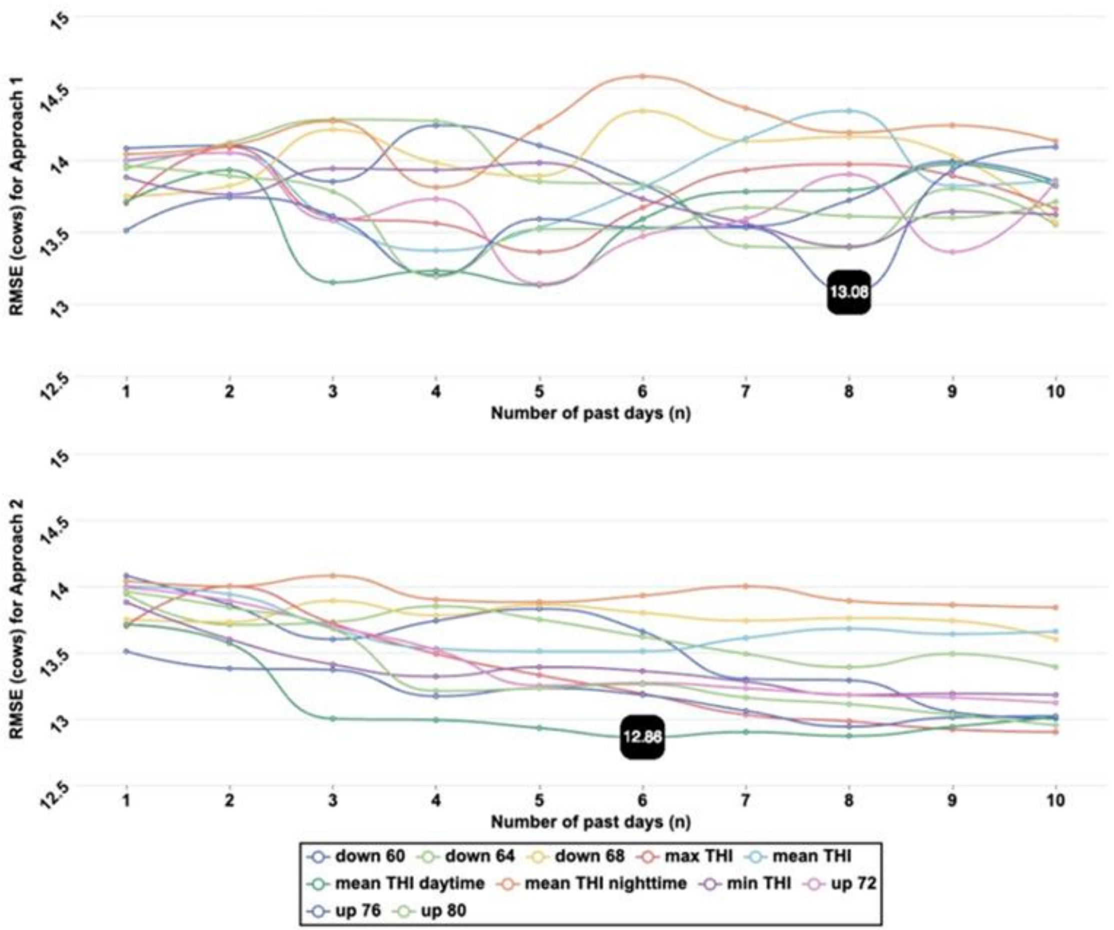
A single variable for each previous n-day period was aggregated to capture the overall environmental conditions across *n* days.

$$(time, current\ THI, accum\ THI, night\ THI, variable_n)$$

Appr 2

Instead of aggregating data across *n* days, consecutive temporal features for each interval from one to *n* days prior are included.

$$(time, current\ THI, accum\ THI, night\ THI, variable_1, \ldots, variable_n)$$



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Final variable selection and model building

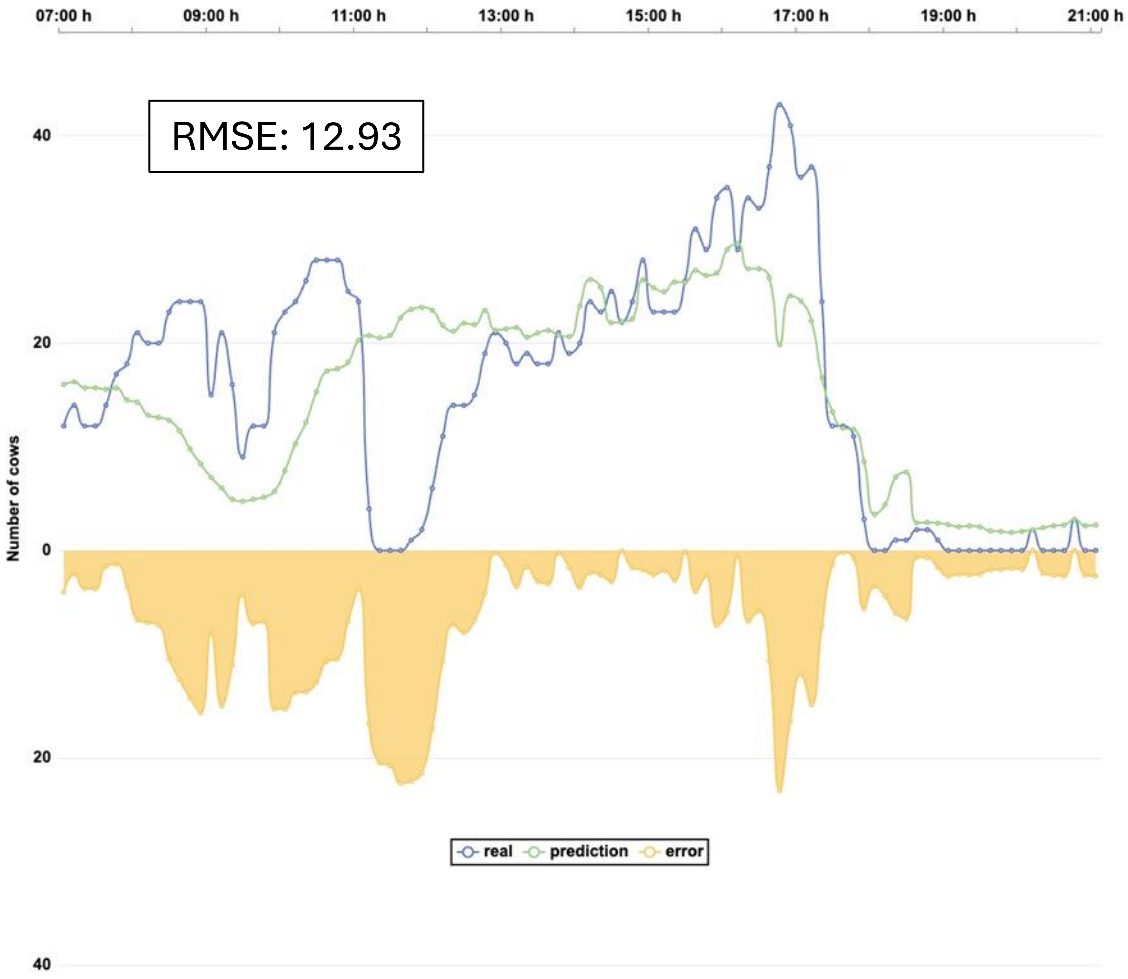
Variables selected based on:

Minimisation of prediction error (RMSE)

Priority given to the earliest days when the error stabilised, to facilitate early detection of heat stress

“down 60”: 7 days.
“up 76”: 8 days.
“max THI”: 7 days.
“min THI”: 3 days.
“mean THI daytime”: 3 days.

$(time, current\ THI, accum\ THI, night\ THI, variable_1, \ldots, variable_n)$



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Take home message

- Shade-seeking behaviour in Holstein heifers is significantly correlated with heat stress, making it a useful and non-invasive proxy for assessing animal welfare under high temperatures.
- Cumulative values over several days and their diurnal/nocturnal variability have greater predictive power over animal behaviour.
- The final random forest-based model reduced the prediction error (RMSE) by 13.6% compared to the original model.
- In this current context, heifer behaviour changes significantly when THI exceeds 76, in contrast to the classic THI threshold of 72.
- The integration of ML and PLF allows the development of early warning systems and specific management strategies to mitigate heat stress.

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