Coupling precision livestock farming technologies with artificial intelligence for mitigating heat stress in Mediterranean dairy cattle systems

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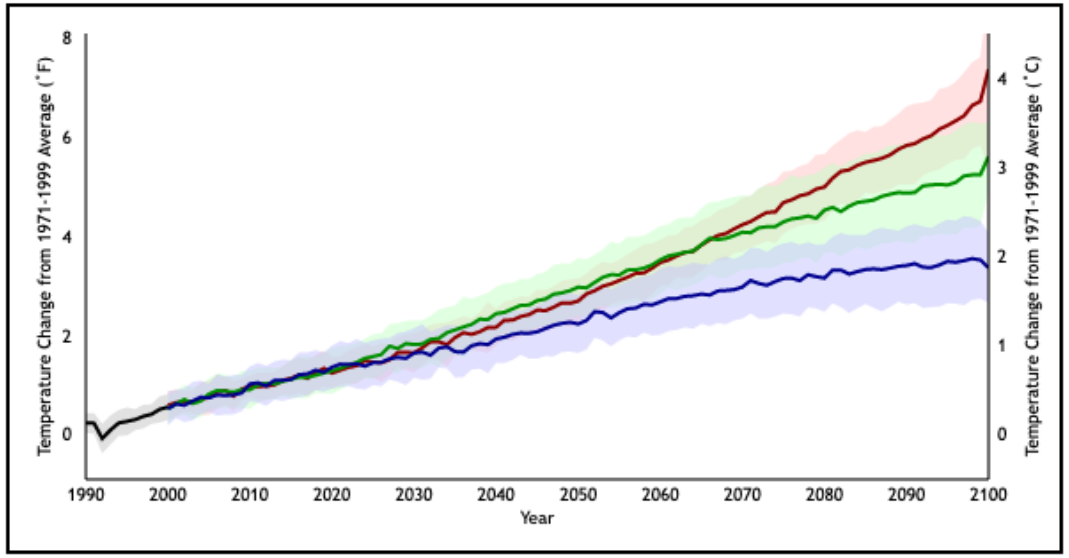
Climate change as a key burden for sustainable animal production



Source: www.climate.gov

Innovative approaches are needed to tackle heat stress

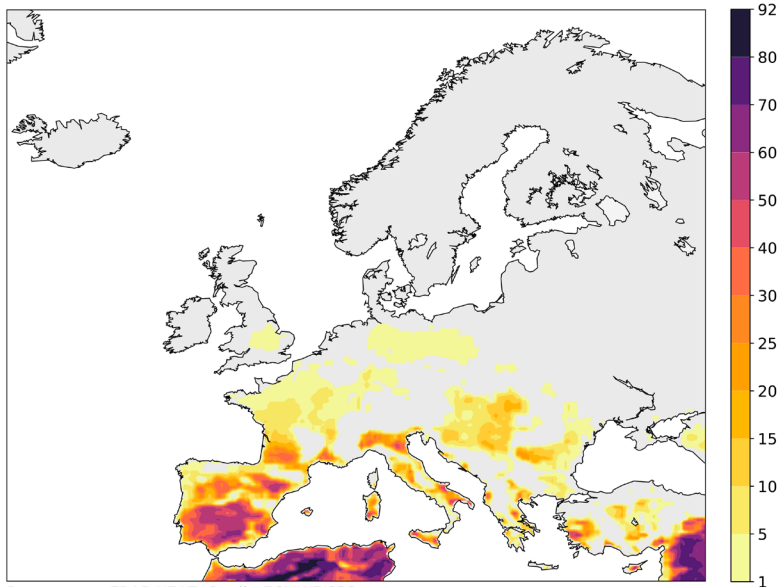
Temperature humidity index (THI) (NRC, 1971) as a proxy for heat stress

$$THI = (1.8 \times Temp + 32) - (0.55 - 0.0055 \times RH) \times (1.8 \times Temp - 26)$$

C	20	30	40	50	60	70	80	90	100
22	66	66	67	68	69	69	70	71	72
24	68	69	70	70	71	72	73	74	75
26	70	71	72	73	74	75	77	78	79
28	72	73	74	76	77	78	80	81	82
30	74	75	77	78	80	81	83	84	86
32	76	77	79	81	83	84	86	88	90
34	78	80	82	84	85	87	89	91	93
36	80	82	84	86	88	90	93	95	97
38	82	84	86	89	91	93	96	98	100
40	84	86	89	91	94	96	99	101	104

Source: www.glycal-forte.com

Number of days that experienced very strong heat stress - JJA 2022



Data source: ERA5-HEAT, Credit: ECMWF/C3S

Copernicus Climate Change Service
European State of the Climate | 2022

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Adapted and context-specific solutions are needed

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Re-Livestock
RESILIENT FARMING SYSTEMS

Offering solutions towards more sustainable animal production

Improve animal welfare

Reduce negative environmental impacts

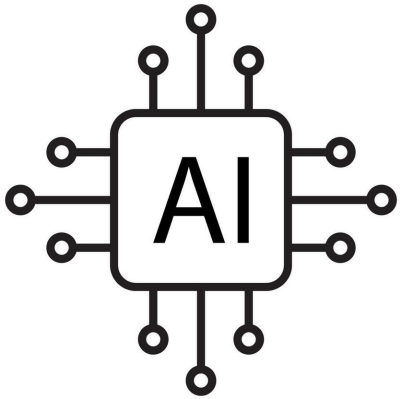
PRECISION LIVESTOCK FARMING

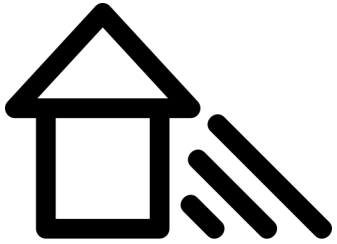
Source: © Nesterenkoruslan

Increase production efficiency

Reduce workload and improve quality of life

Coupling of PLF technologies, AI and heat protection





Aim

Optimization of artificial intelligence models to predict the number of animals under heat stress mitigation facilities in Mediterranean conditions.

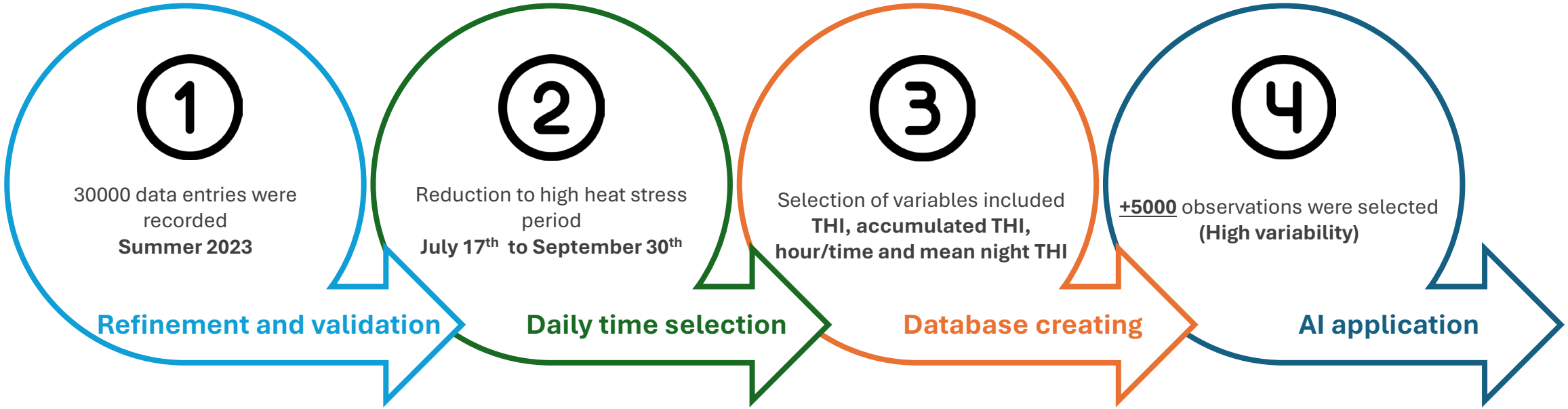
Materials and Methods

- **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

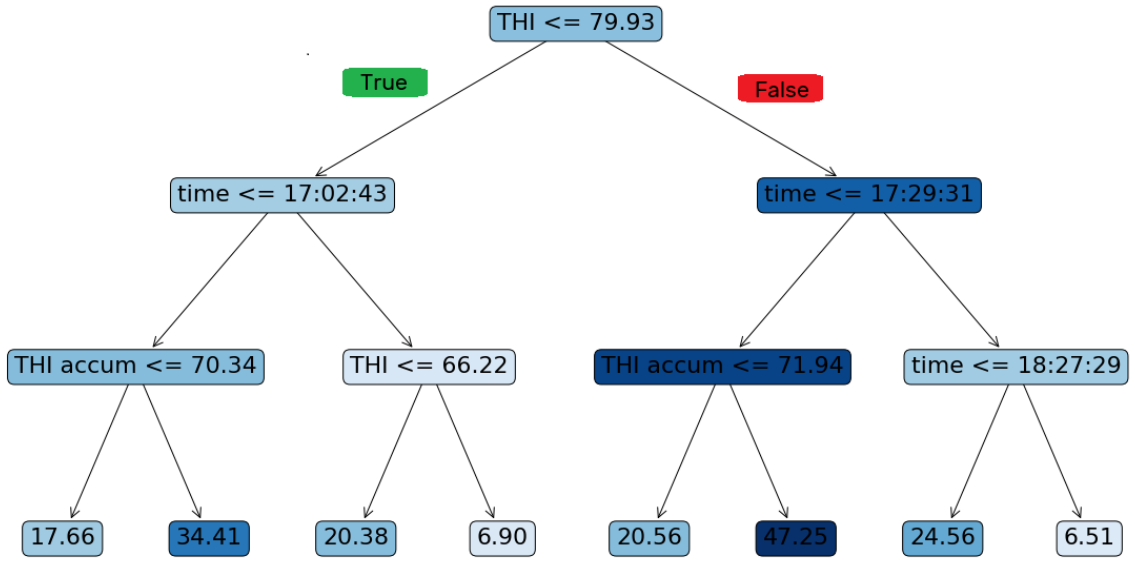
- **Data collation and pre-processing**



Random forest

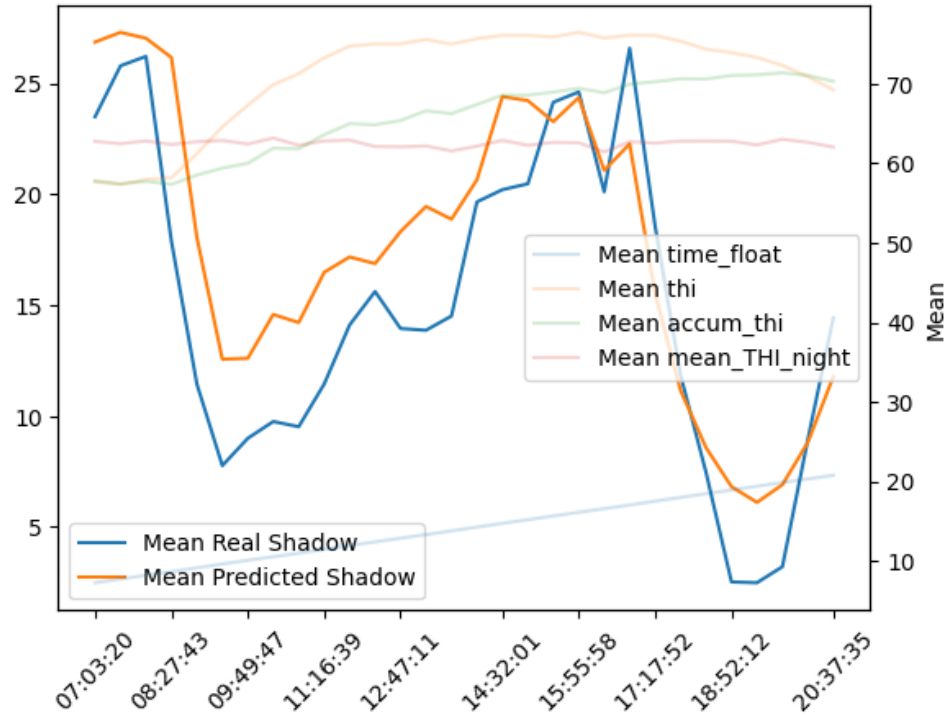
AI algorithm that combines the output of multiple decision trees to reach a single result-prediction

From the tree to the forest



3 variables included

THI, accumulated THI and hour/time



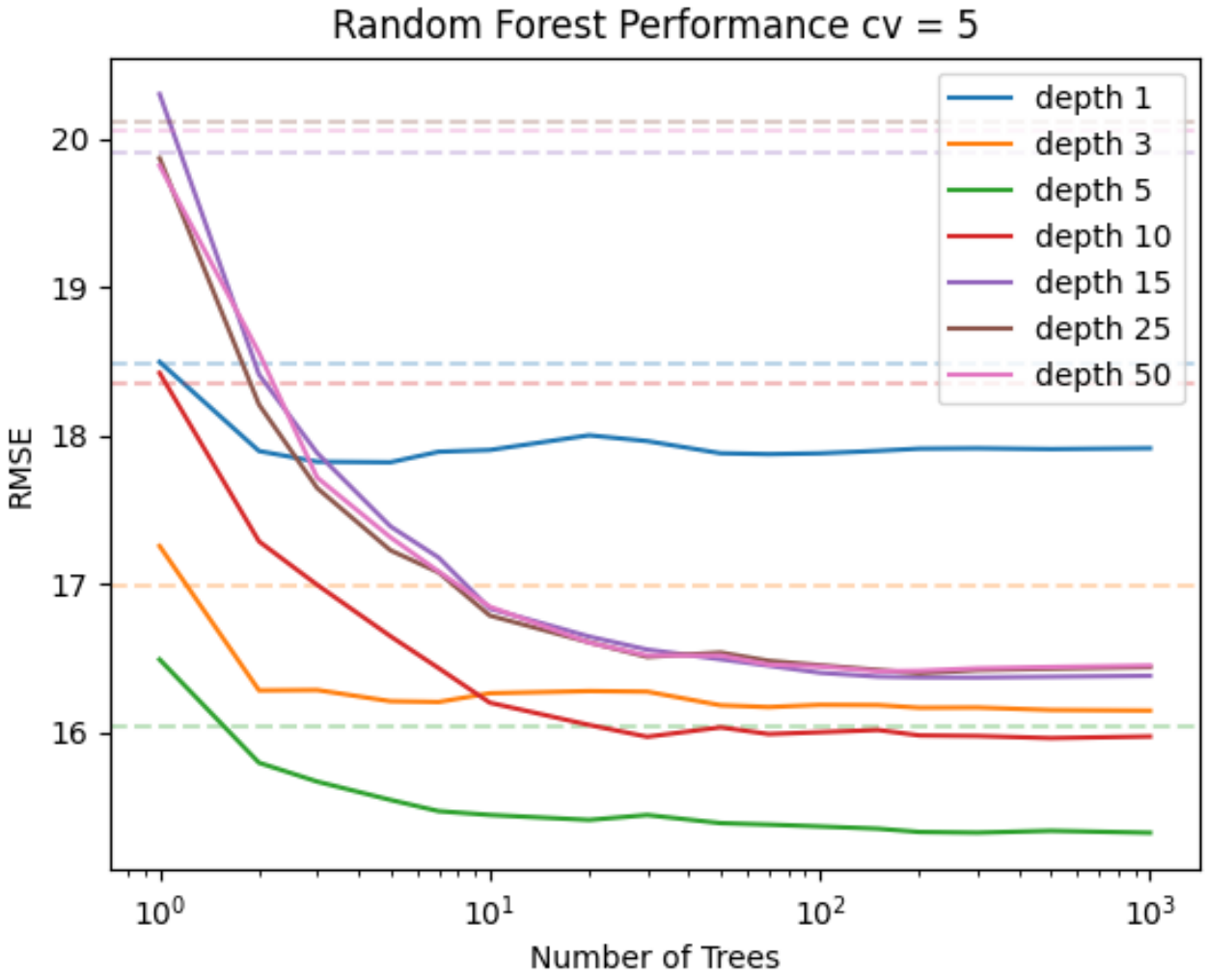
4 variables included

THI, accumulated THI, hour/time and mean night THI

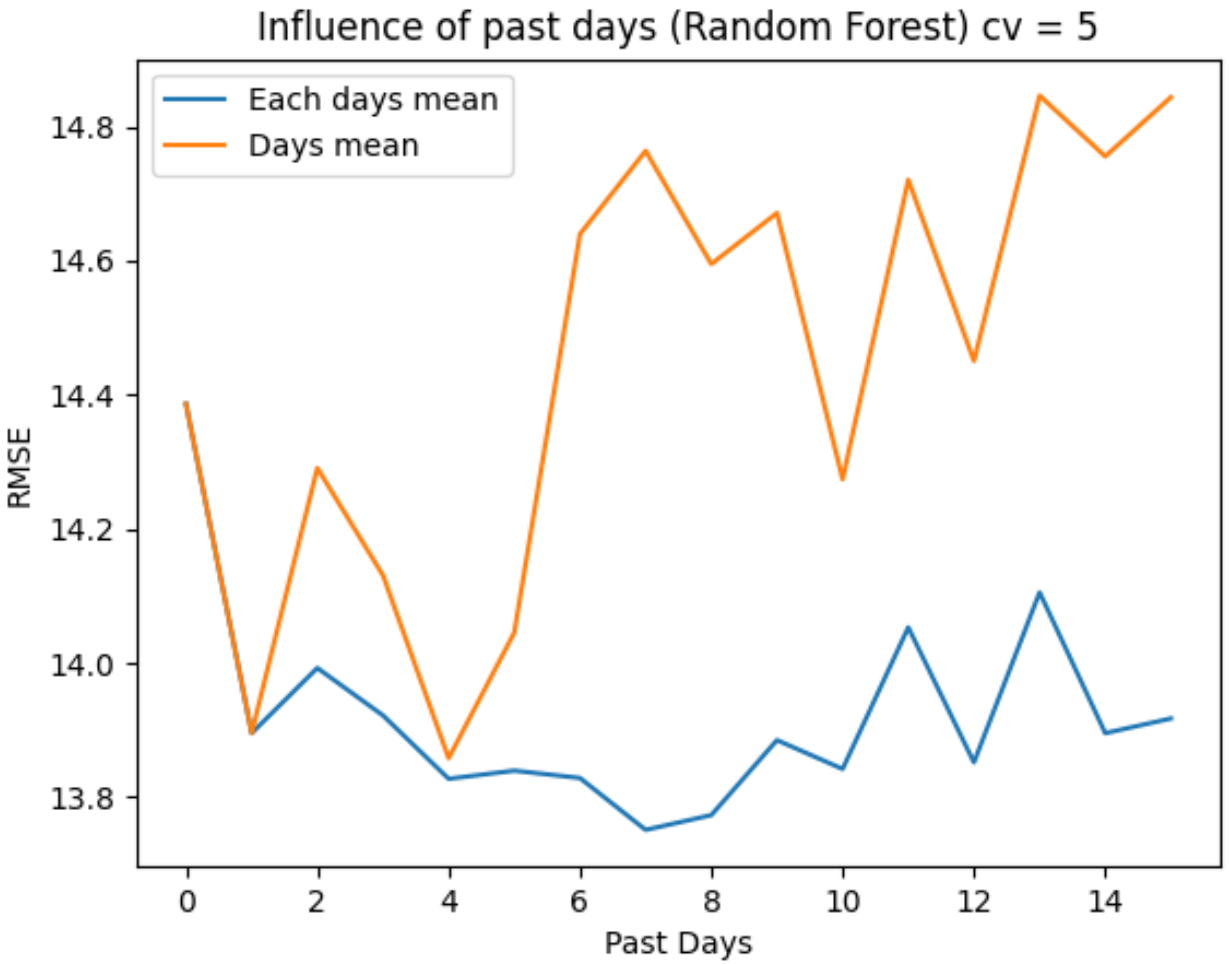
(Random forest with 10 trees and a depth of 5)

Looking for the best prediction: The forest

- Mean square error of different random forests trained with different depths and numbers of trees.
- The dashed line indicates the error of the corresponding decision tree (single tree).
- Results have been extracted using a cross validation with 5 sets, for a more accurate estimation of the error.



Looking for the best prediction: The variables



New variables were added to the previous ones

- Assumption that the previous THI values have a relevant influence on the animal behaviour toward heat stress.
  - Individual mean THI of the past days (**Orange**)
  - Added mean THI of the past days (**Blue**)

Cut-off points were identified according to the RMSE.

- Optimization of the data to retain to get the best prediction values.

Take home message

- The results demonstrate the **effectiveness of combining AI algorithms with PLF tools** for detailed analysis of animal behaviour under different heat conditions.
- To facilitate decision-making on livestock facilities in order to optimise them to the existing productive and environmental contexts: **Expected number of animals → Environmental conditions**
- This approach could identify by means of ranking the **most suitable variables and AI approaches** for an optimal prediction of animal counts.
- **Future research avenues** have been identified to determine the most appropriate variable typology as well as the factors contributing to the use of shadows (i.e., new metrics, new individual monitoring technologies, etc.).

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