



TOWARDS IMPROVEMENT OF RUMINANT BREEDING  
THROUGH GENOMIC AND EPIGENOMIC APPROACHES

## Towards new breeding tools in a context of climate change: first results of the RUMIGEN project on new phenotypes for heat tolerance traits

S. Mattalia, A. Vinet, J. Vandenplas, M.J. Carabaño, C. Diaz,  
M. Ramon, S. Aguerre, B.C.D. Cuyabano, D. Boichard, E.  
Pailhoux & H.A. Mulder

ICAR Meeting

(Montréal, Canada, May 30-June 3, 2022)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000226



### **Provide breeding tools :**

- Improve efficiency & resilience, **in a context of climate change**
- Maintain genetic diversity

### **A large panel of competences:**

#### **(i)quantitative genetics**

- Heat tolerance traits, genetic diversity

#### **(ii)epigenetics**

- How genome and epigenetics do shape the phenotypes?

#### **(iii)new breeding techniques**

- Genome integrity using genome editing

**With a Human Social Sciences lever**, to build breeding tools in line with social expectations (co-construction of new breeding schemes)

## Objective of the study

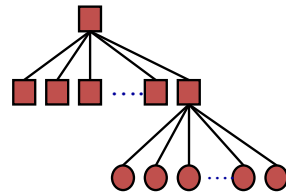
**Measure the impact of heat stress on the performances of dairy cows  
at the population level**

Based on existing large scale national data:

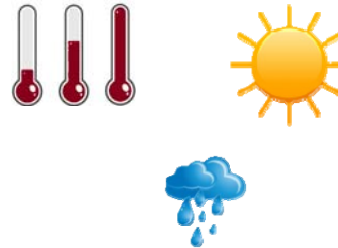
Phenotypes



Pedigrees



Weather (daily records)  
associated to each herd



1. Study in each country separately, using the same approach (**production, health, reproduction**)
2. Comparison of results

## Material



Holstein (FRA, SPA, NLD)



Montbéliarde (FRA)



MRY (NLD)

**Performances:** Test-Day records on Milk Yield (MY), Fat Yield (FY), Protein Yield (PY), Fat Content (FC), Protein Content (PC) and Somatic Cell Score (SCS)

- Periods from past 5 to 11 years, pending the country (NLD: 2010-2020; SPA: 2010-2021; FRA: 2016-2020)
- $\approx$  7 Mo French, 500,000 Dutch and 1 Mo Spanish Holstein cows,
- $\approx$  10,000 Dutch MRY and 1.2 Mo French Montbéliarde cows

**Daily weather information** associated to each farm:

• Provided by national Meteo Agencies

- France : Grids of 8x8 km
- Spain : 1,993 weather stations
- NLD : 34 weather stations

**Temperature Humidity Index**

$$THI = (1.8 * T + 32) - (0.55 - 0.0055 * RH) * (1.8 * T - 26)$$

With T: average daily temperature (°C); RH: average daily humidity

## Method

### → Estimation of the effect of a variation of THI at the population level:

Each lactation analysed separately

Cow  $i$ , TD  $j$ , submitted to a given THI

$$y_{ij} = \text{THI} + \sum \text{other fixed effects}_{i,j} + a_i + p_i + e_{ij}$$

With

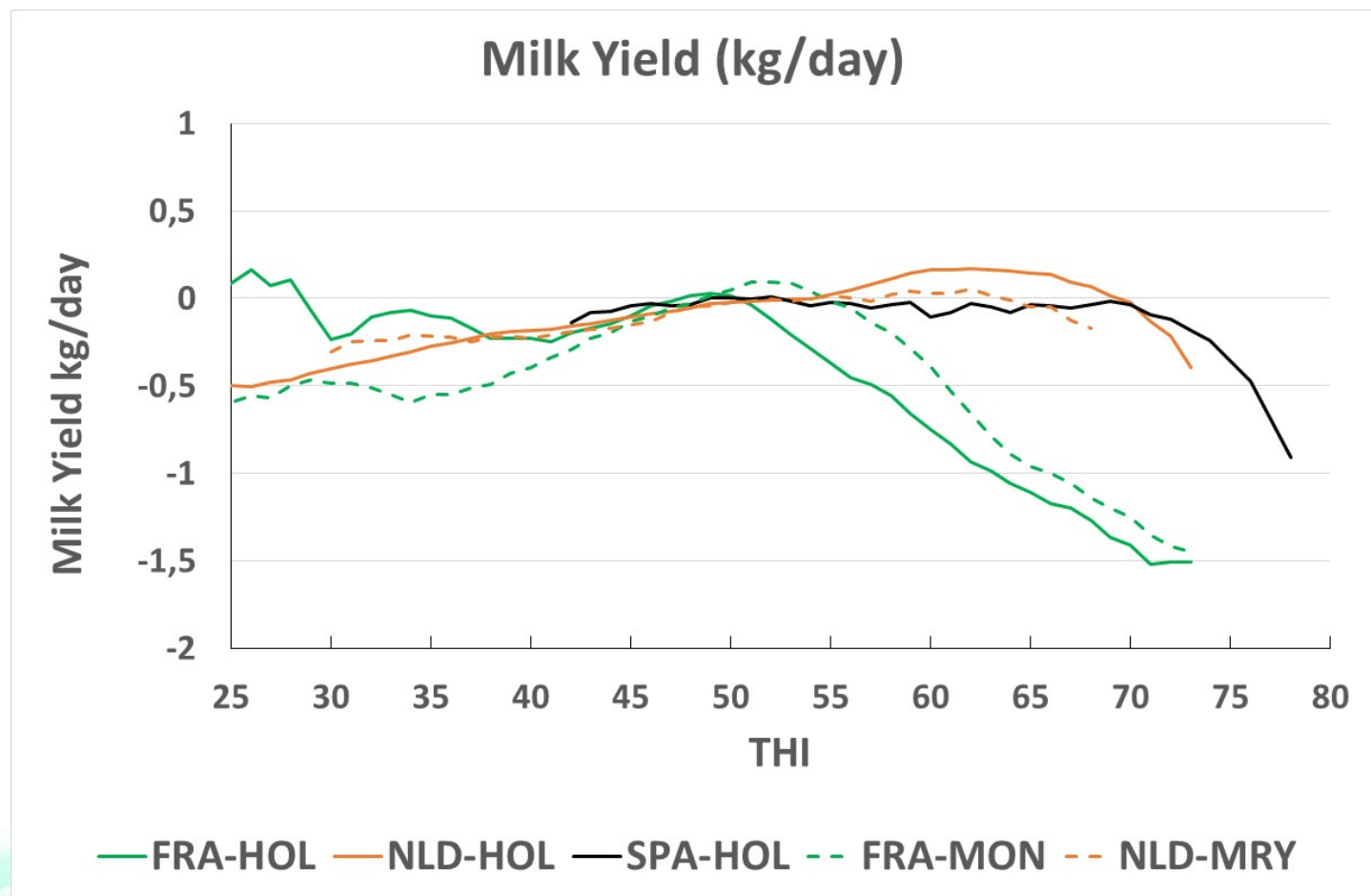
- $y_{ij}$ : performance of the cow
- Random effects:  $a_i$  additive genetic value,  $p_i$  : permanent effect,  $e_{ij}$ : residual
- THI (fixed): averaged within 3 days before the TD
- Fixed effects (other than THI)
  - FRA: Herd-Year, DIM, gestation stage, month of calving and age at calving;
  - NLD: Herd-Year, DIM, gestation stage, age at calving–year– season
  - SPA: Herd-Year-Season, DIM, age

## Results

### Estimated effect of THI on Milk Yield - Cows in 1st lactation -

Estimated  
THI effects  
averaged  
using a rolling  
basis  
of 5 THI units

For each  
breed-country:  
 $\widehat{THI}(50) = 0$



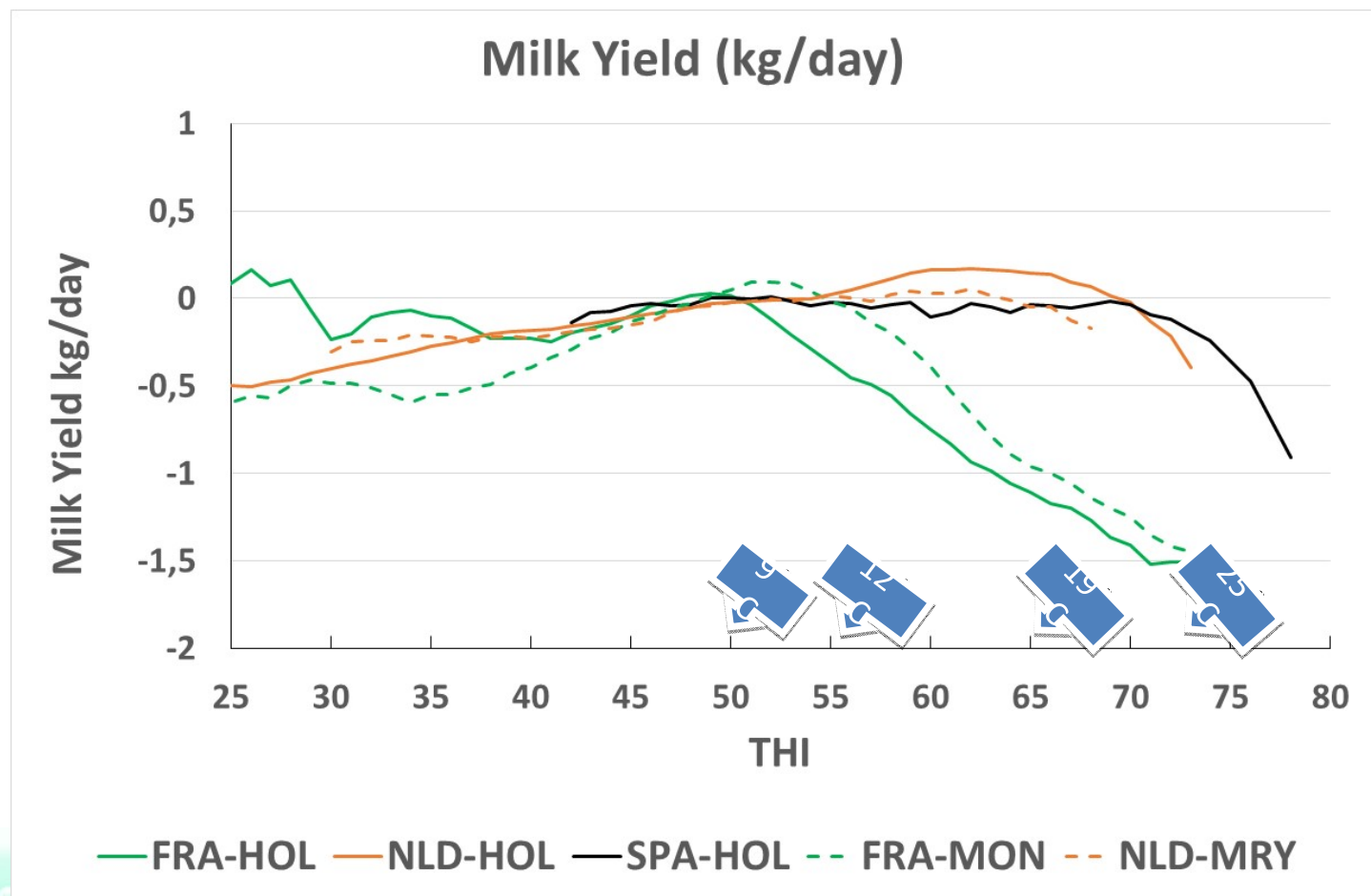


## Results

### Estimated effect of THI on Milk Yield - Cows in 1st lactation -

Estimated  
THI effects  
averaged  
using a rolling  
basis  
of 5 THI units

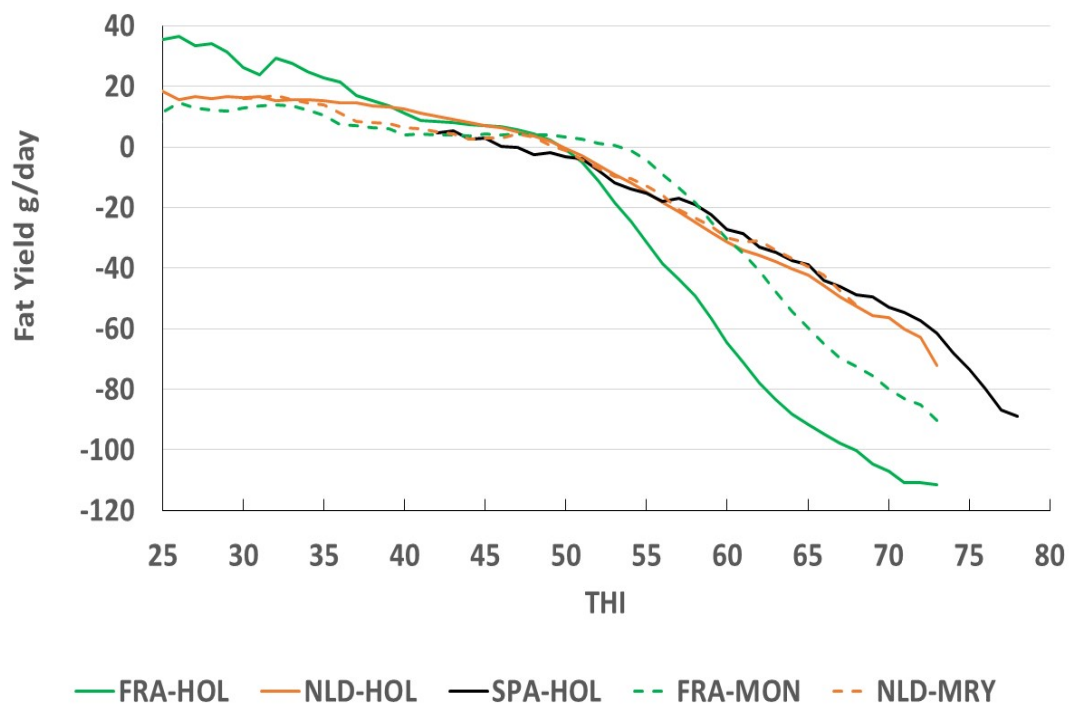
For each  
breed-country:  
 $\widehat{THI}(50) = 0$



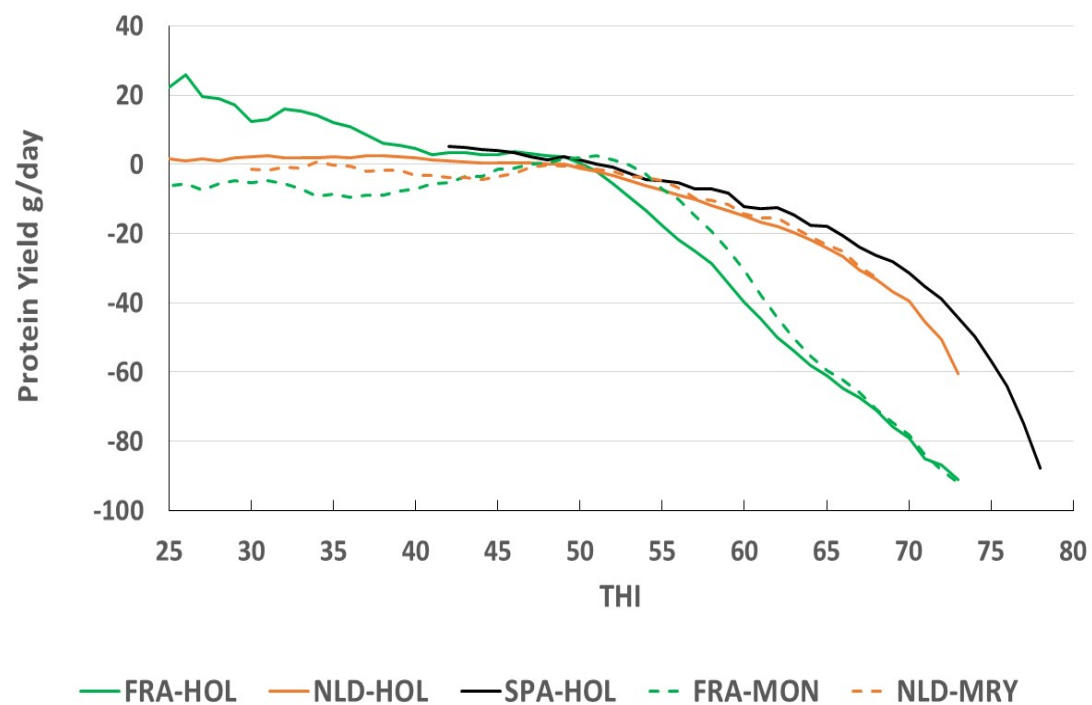
## Results

### Estimated effect of THI on Fat and Protein Yields - Cows in 1st lactation -

Fat Yield (g/day)



Protein Yield (g/day)

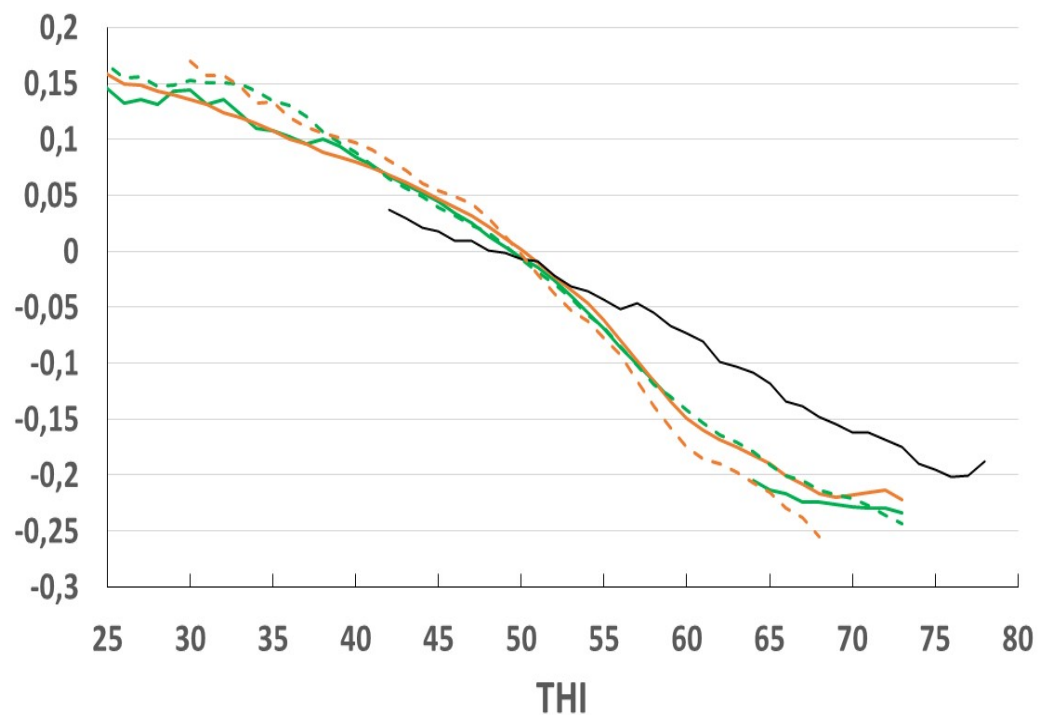




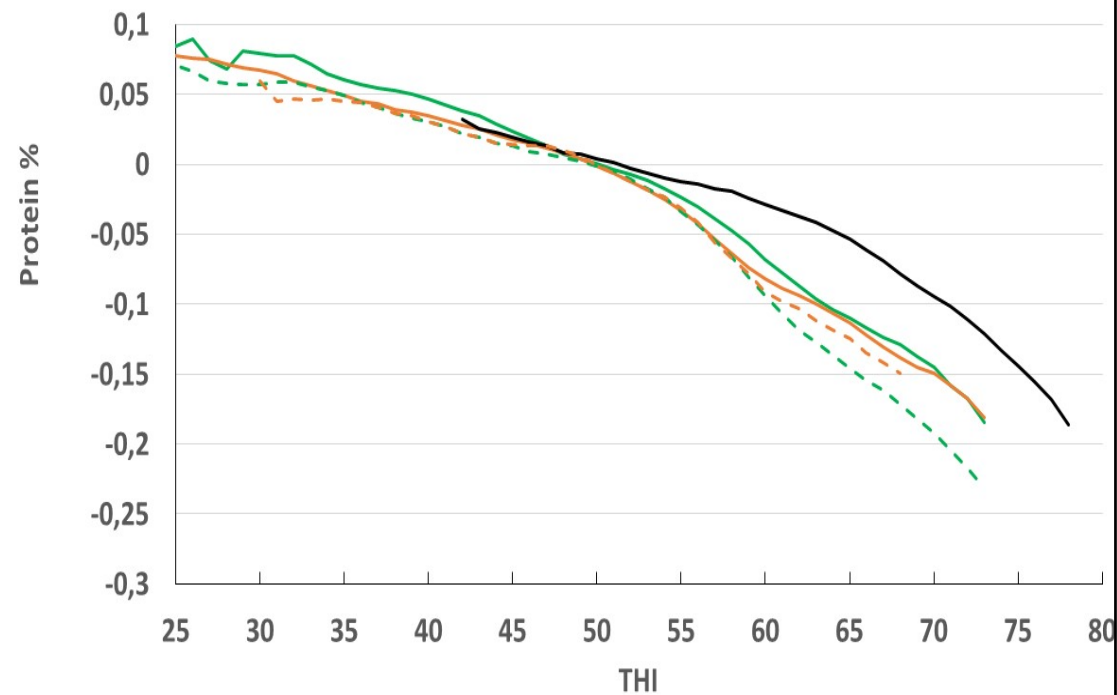
## Results

### Estimated effect of THI on Fat and Protein Contents - Cows in 1st lactation -

Fat content (%)

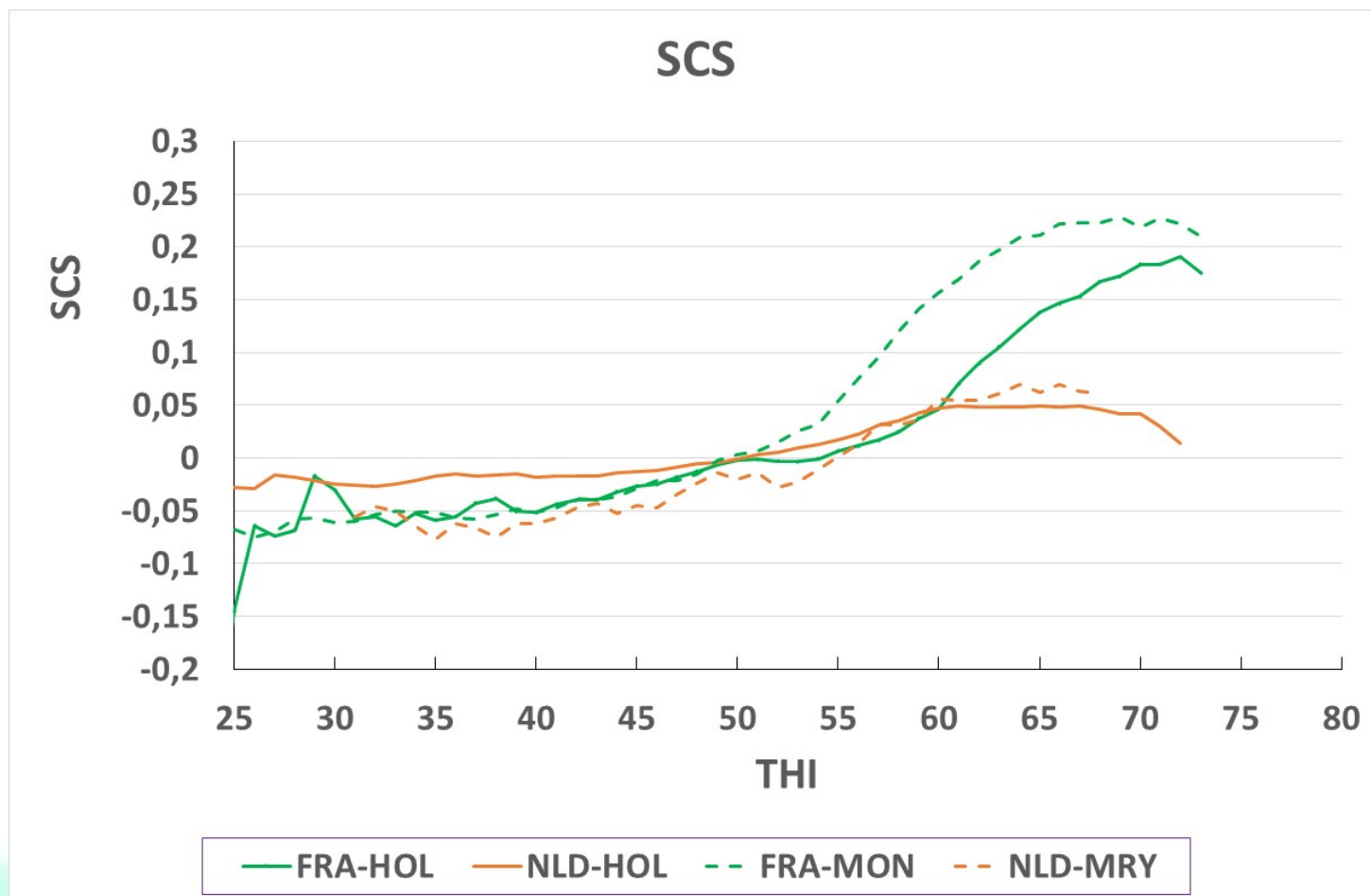


Protein content (%)



## Results

### Estimated effect of THI on SCS - Cows in 1st lactation -



## Discussion

- **A negative impact of increasing THI on performances**
  - Stronger on production than on SCS
    - Eg.: MON, FRA, L1: THI 50->70 :
      - PY: -84 g/day  $\leftrightarrow$  11% of daily average production  $\leftrightarrow$   $0.7 \sigma_p$
      - SCS: +0.22  $\leftrightarrow$  SCC x 1.3  $\leftrightarrow$   $0.2 \sigma_p$
  - The pattern of the curves depended on the trait
- **More differences between countries than between breeds**
  - FRA (yields): HS thresholds lower than expected / literature and / SPA and NLD
  - Farming conditions ?
    - Dutch cows: 2/3 farms of this study equipped with robots (large farms)
    - Spanish cows: not exposed to outdoor conditions, barns better equipped to mitigate heat stress
    - French cows: more pasture (outdoor  $\rightarrow$  more exposure to HS, feeding)
  - Spain: acclimatation?
  - ...

## Conclusion

- Heat Stress indicators can be defined, combining performances & weather data
- A negative impact of heat stress, stronger on production than on SCS
  - The pattern of the curves depended on the trait
  - → Heat tolerance is a complex trait
- Consistant patterns between breeds & countries
- HS thresholds: more differences between countries than between breeds
  - Farming systems
  - Acclimatation
  - ...
  - ... to be confirmed!
- Next step:
  - Reproduction traits
  - Genetic determinism of heat tolerance traits

# Acknowledgement



GEMGepSV



***This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000226***

*Disclaimer: the sole responsibility of this presentation lies with the authors.*

*The Research Executive Agency is not responsible for any use that may be made of the information contained therein.*

## RUMIGEN PARTNERS

*Thank you for your attention*



[www.rumigen.eu](http://www.rumigen.eu)



*This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 101000226*

*Disclaimer: the sole responsibility of this presentation lies with the authors.*

*The Research Executive Agency is not responsible for any use that may be made of the information contained therein.*