



TOWARDS IMPROVEMENT OF RUMINANT BREEDING  
THROUGH GENOMIC AND EPIGENOMIC APPROACHES

# RUMIGEN : New breeding tools in a context of climate change: Impact of heat stress on the performances of dairy cows at the population level

S. Mattalia, A. Vinet, M.P.L. Calus, H. A. Mulder, M.J. Carabaño,  
C. Diaz, M. Ramon, S. Aguerre, J. Promp, R. Vallée, B.C.D.  
Cuyabano, D. Boichard, E. Pailhoux & J. Vandenplas



EAAP Meeting

(Lyon, France, Aug. 28<sup>th</sup>- Sept. 1<sup>st</sup>, 2023)



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



**Period: 2021-2026**

**Provide breeding tools (dairy cows) :**

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

**A large panel of competences:**

**(i) quantitative genetics**

- Heat tolerance traits, management of genetic diversity

**(ii) epigenetics**

- How genome and epigenetics do shape the phenotypes?

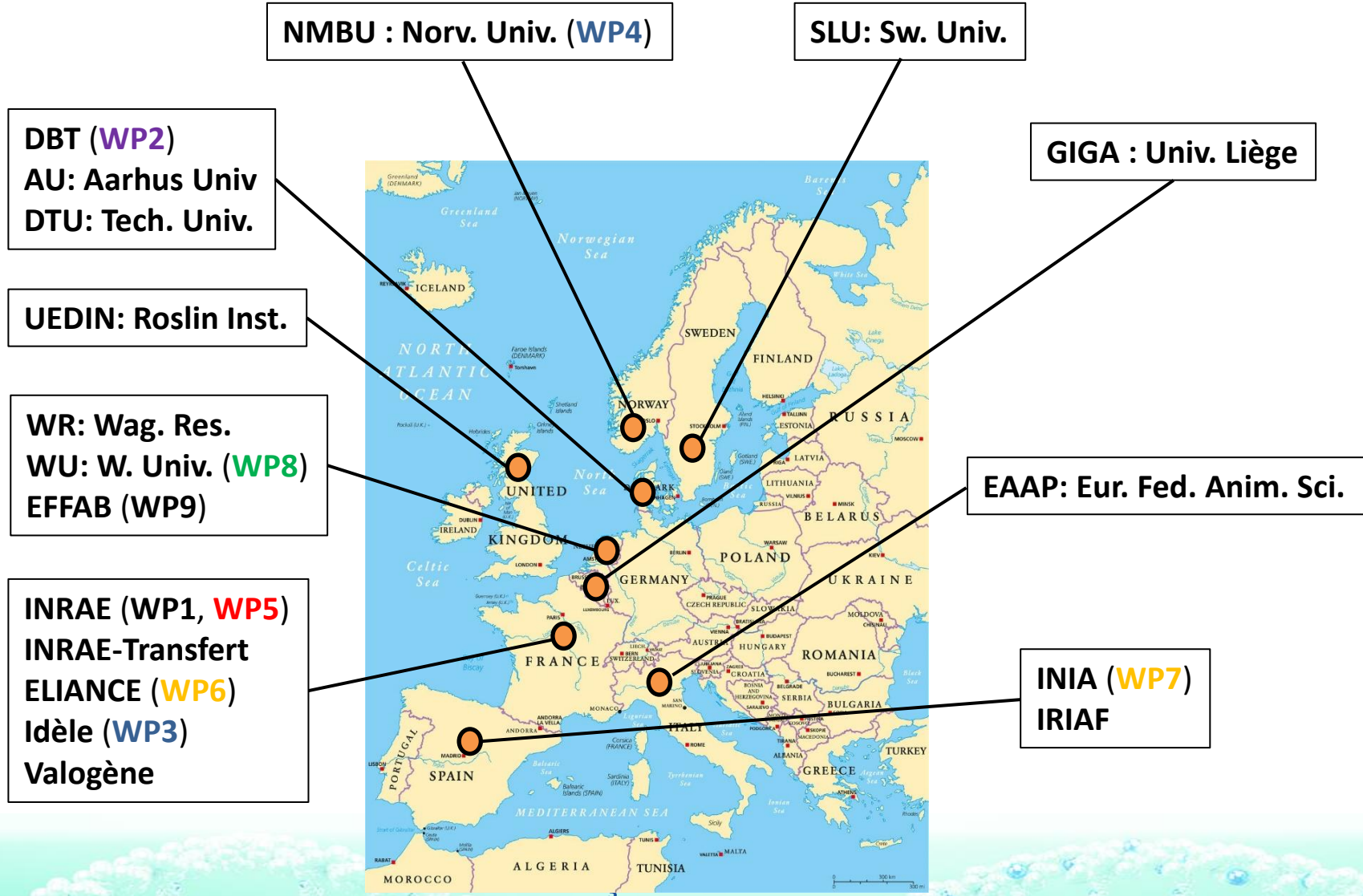
**(iii) new breeding techniques**

- Genome integrity using genome editing

**With Human Social Sciences**, to evaluate societal acceptability of NBT and of breeding strategies in general

# Partnership

18 Partners / 9 countries  
FR<sub>5</sub>; DK<sub>3</sub>; NL<sub>3</sub>; ES<sub>2</sub>; NO; UK; SE; BE; IT



## Objective of the study

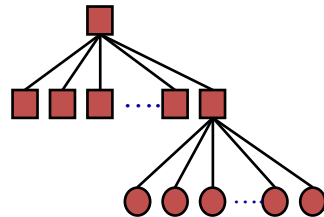
# Measure the impact of heat stress on the performances of dairy cows at the population level

Using existing large scale national data:

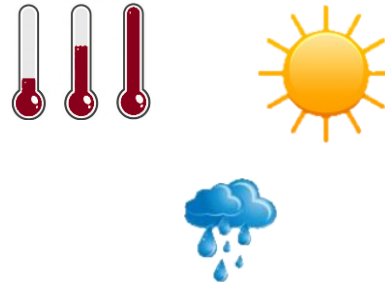
Phenotypes



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

See J. Vandenplas (NLD), M.J. Carabaño (SPA), A. Vinet (FRA), EAAP session 55,  
S. Aguerre, Interbull meeting (meta analysis at individual level)

# Material



Holstein (FRA, SPA, NLD)



Montbéliarde (FRA)



MRY (NLD)

**Performances:** Test-Day records on Milk Yield (MY), Fat Yield (FY), Protein Yield (PY), Somatic Cell Score (SCS), Conception Rate at 1<sup>st</sup> AI

	FRA	NLD	SPA
Period	2016-2020	2010-2020	2010-2021
# cows	7 Mo (HOL) 1.2 Mo (MON)	500,000 (HOL) 10,000 (MRY)	1 Mo (HOL)

**Daily weather information** provided by national Meteo Agencies

- Associated to each herd, using partial ZIP code

**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

(source: National Research Council, 1971)

## 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

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

$$y_i = \text{THI} + \sum \text{other fixed effects}_i + a_i + e_i \quad (\text{CR1})$$

With

- $Y_{ij}$ : performance of the cow
- Random effects:  $a_i$  additive genetic value,  $p_i$  : permanent effect,  $e_{ij}$ : residual
- Production, SCS: THI (fixed): averaged within 3 days before the TD (from d-2 to d0)
- CR1: THI (fixed) averaged within 8 days after AI (from d0 to d7)

# 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

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

$$y_{ij} = \text{THI} + \sum \text{other fixed effects}_{i,j} + a_i + e_{ij} \quad (\text{CR1})$$

With

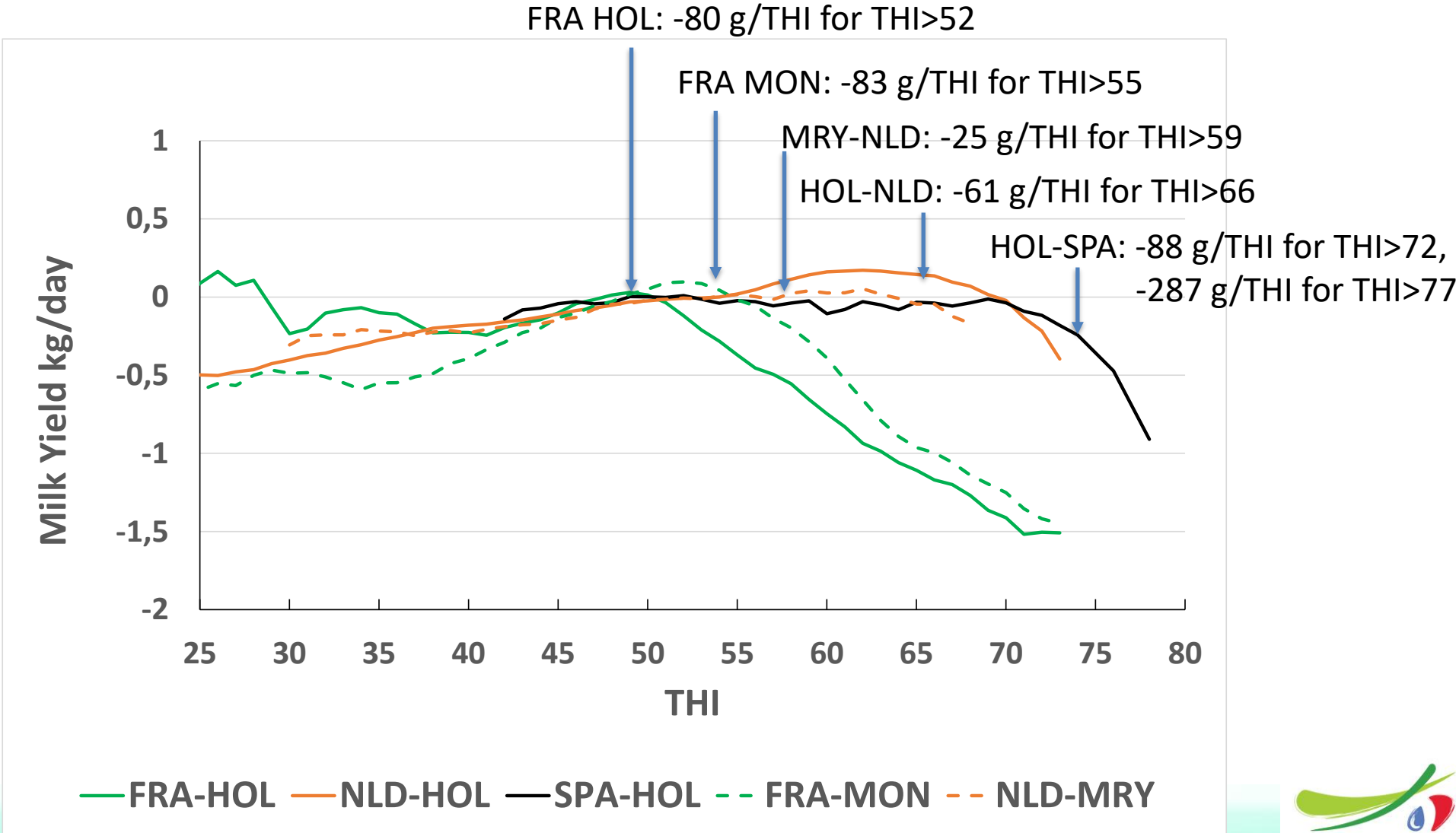
- Fixed effects (other than THI): Production & SCS:
  - FRA: Herd-Year, DIM, gestation stage, month of calving and age at calving;
  - NLD: Herd-Year, DIM, gestation stage, age at calving–year– season
  - SPA: Herd-Year-Season, DIM, age at calving
- Fixed effects (other than THI): CR1:
  - FRA: herd-Year, DIM, week day, age at insemination, sexed semen-year
  - NLD: mean, herd-year, year-month, week day, age at calving, sexed semen
  - Spain: herd-year, DIM, age at calving

# 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:  
 $\widehat{THI}(50) = 0$

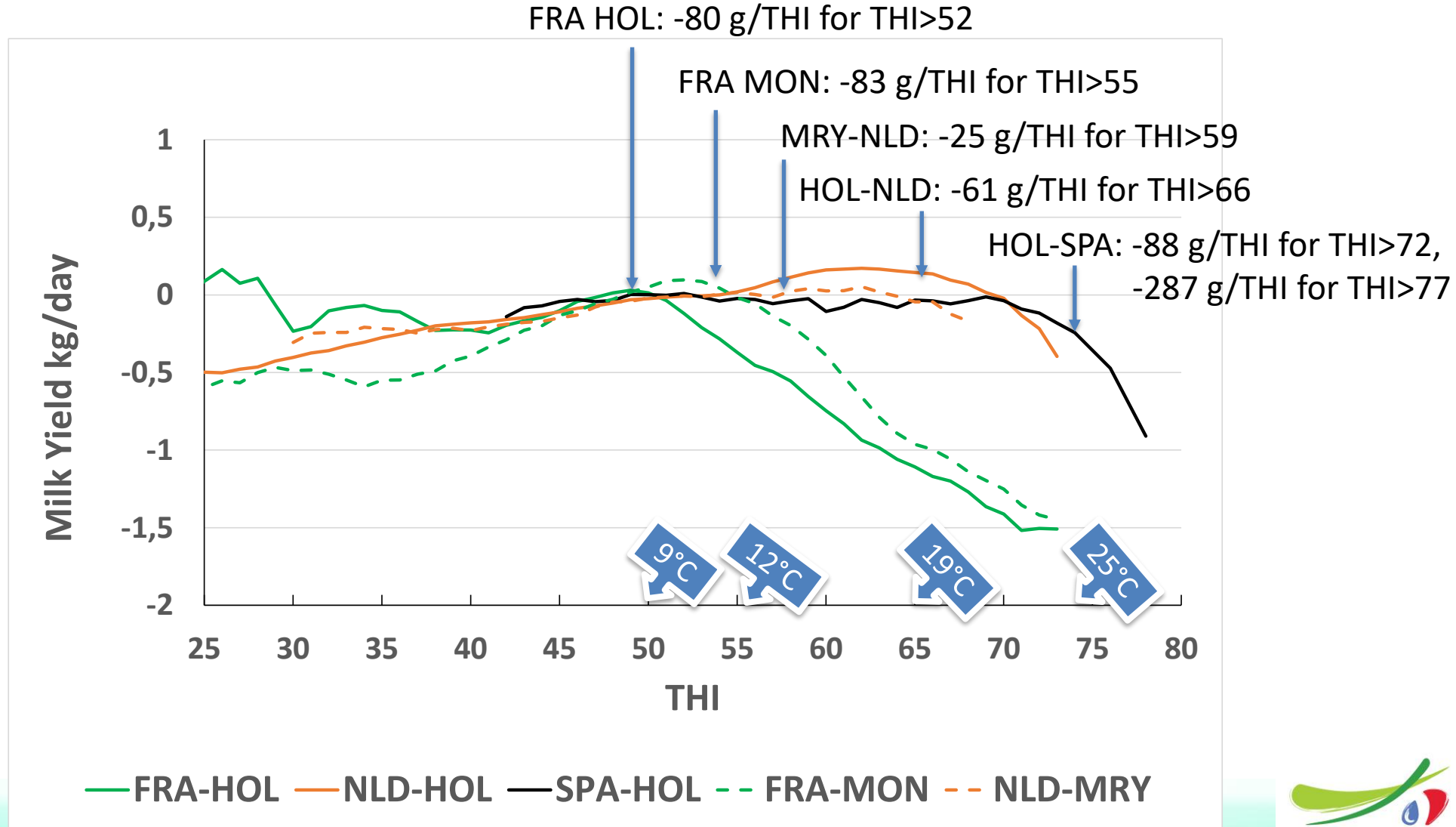


# Results

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

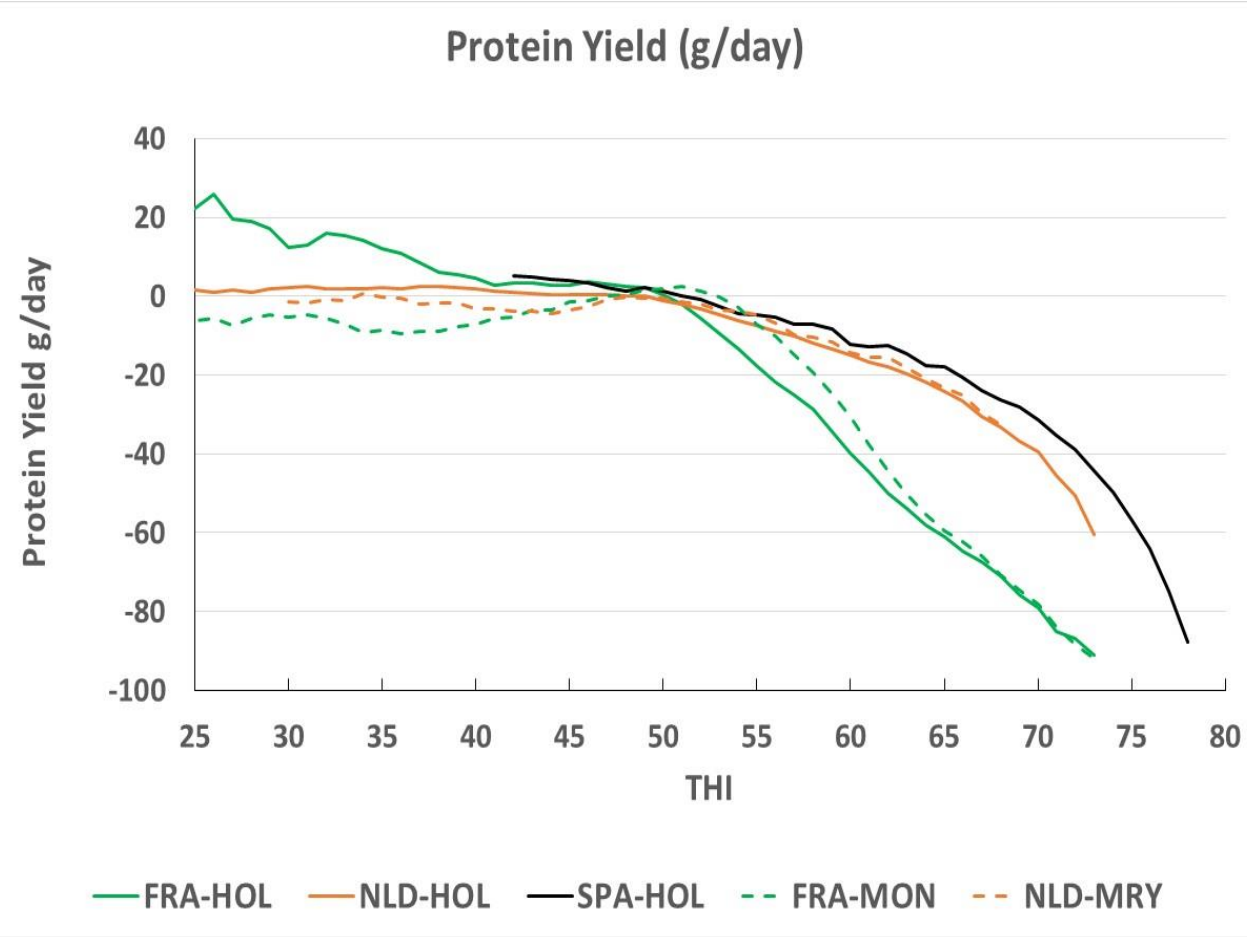
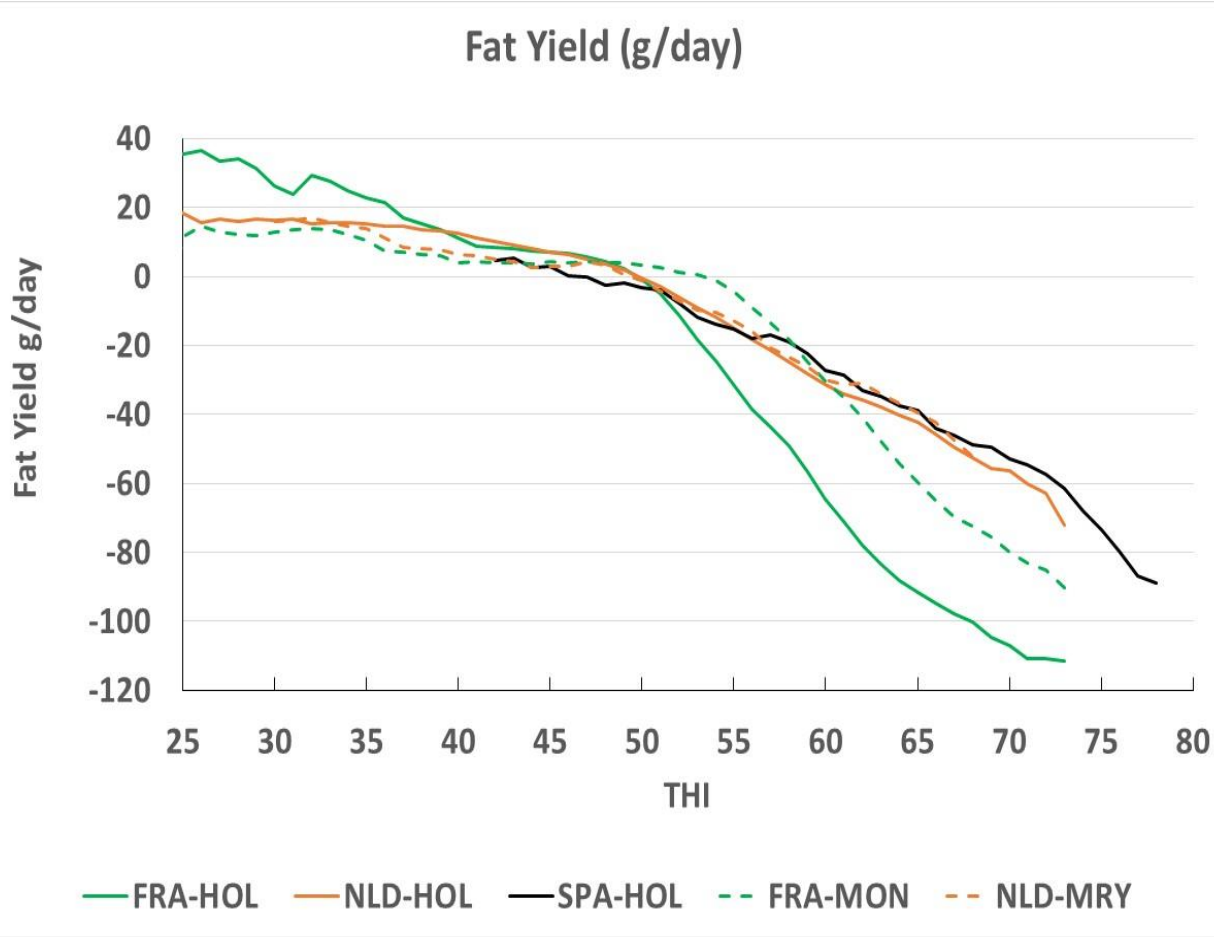
Estimated THI effects averaged using a rolling basis of 5 THI units

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

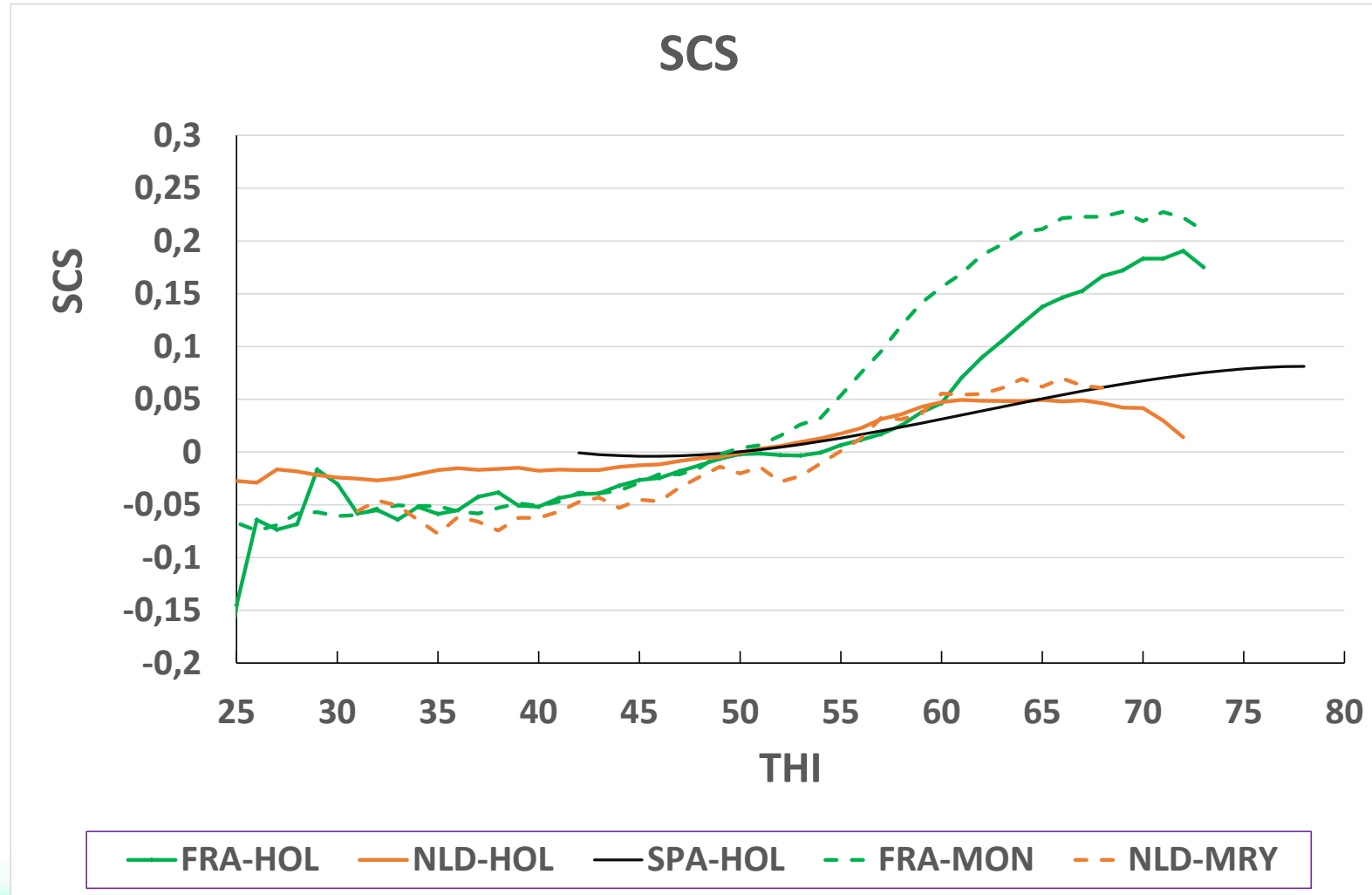


# Results

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

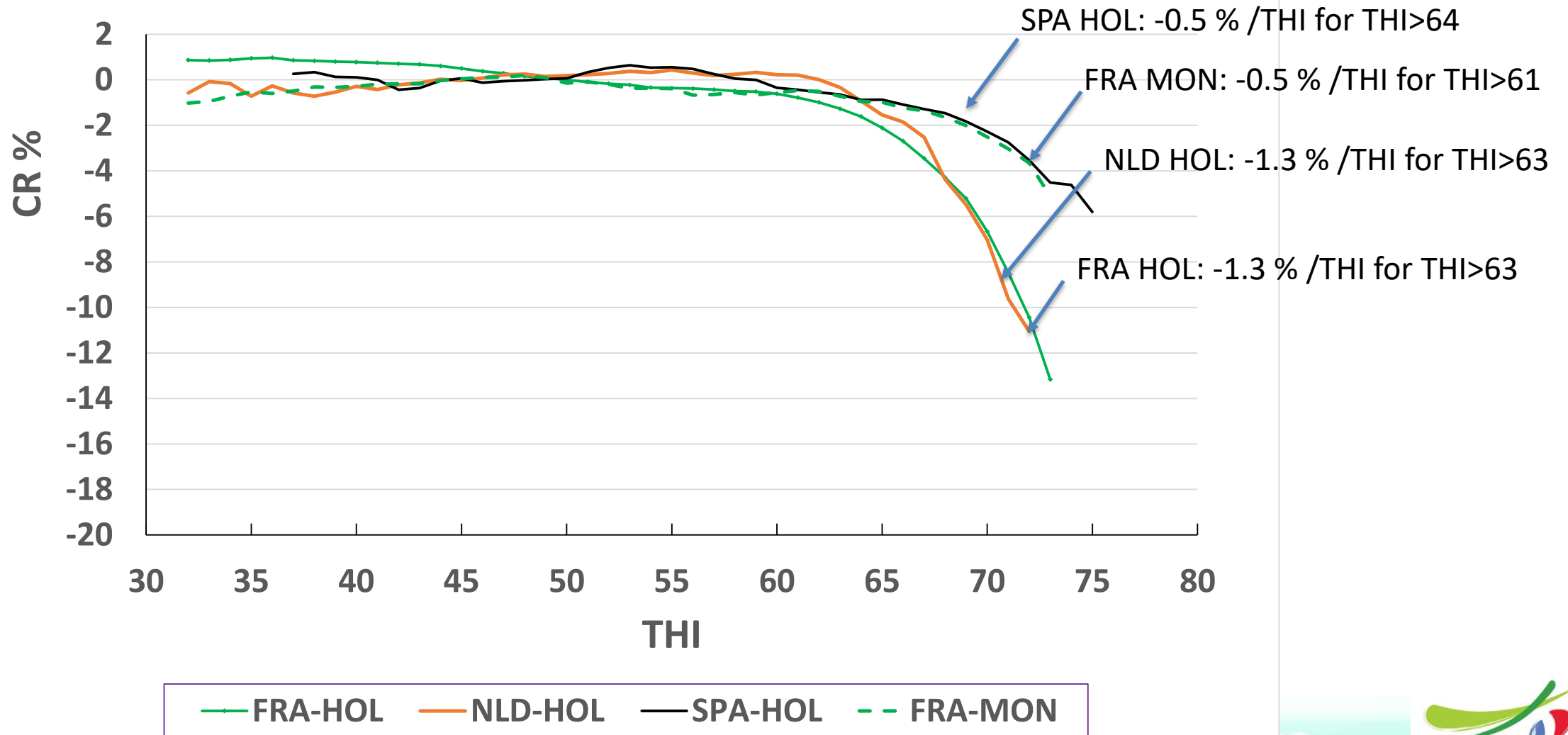


## Estimated effect of THI on SCS - Cows in 1st lactation -



# Results

## Estimated effect of THI on conception rate – 1<sup>st</sup> AI - Cows in 1st lactation -



# Discussion

- **A negative impact of increasing THI on all performances**
  - Eg. Production, France: ↗ THI from 50 to 70 ↔ 6 to 11% of the daily production
  - Fertility, French and Dutch HOL: ↗ THI from 50 to 70 ↔ -10 % of CR
- **Production, SCS: some differences of thresholds observed across countries**
  - **More differences between countries than between breeds**
    - **Farming conditions ?**
      - Exposure to outdoor weather conditions
        - French cows: large proportion of farming systems with pasture
        - Dutch cows: farms of this study : very large farms
        - Spanish cows: not exposed to outdoor conditions
      - Pasture (France) : confusion betw. moderate THI and transition periods from indoor to pasture rations
      - Spain: strong experience with high t° → barns better equipped to mitigate heat stress
      - ... **to be confirmed with information on farm conditions** (systems, barns, feeding...)
    - **Spain: acclimatation?**
    - ...
- **Conception rate:**
  - **Thresholds are more homogeneous**
  - **Steeper decline for French and Dutch Holsteins than for French Montbéliarde and Spanish Holstein cows**
    - Spain: acclimatation?
    - Montbéliarde : genetic abilities?

# Conclusion

- **A negative impact of increasing THI for all traits**
- **Consistent patterns between breeds & countries**
  - But for production, SCS : more differences between countries than between breeds
    - Low thresholds  $\neq$  animal welfare (stress)
      - Next steps: studied traits (levels of a performance at a given THI, slope) : at a THI > threshold
  - **The pattern of the curves depends on the trait**
- → **Traits on Heat tolerance can be defined**, combining performances & weather data
- → **Heat tolerance is a complex trait**

# Acknowledgement



## CAICalor



*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.*