FACULTY OF BIOSCIENCE ENGINEERING

DEPARTMENT OF DATA ANALYSIS AND MATHEMATICAL MODELLING

Hot topic: novel weather features to quantify heat stress in dairy cows in moderate climatic conditions

Ines Adriaens, Martin Gote, Torsten Pook, Istvan Fodor, Harmen Doekes, Jan Verwaeren, Ben Aernouts

EAAP Florence – Wednesday September 4th, 2024 – session 84

GHENT UNIVERSITY

KU LEUVEN

WAGENINGEN UNIVERSITY & RESEARCH

https://www.europarl.europa.eu/topics/en/article/20180905STO11945/infographic-how-climate-change-is-affecting-europe

Mediterranean region

More heat extremes
Less rain and river flows
Higher risk o
Higher risk of
Higher risk of

More competitic
More water neec
Lower crop yields
Livestock producti
difficult
Pro
More
Less t
in othe
Most ec
Very vuln
climate ch

More people
More areas w
from insect bit

Atlantic reg

More heavy rain
Higher river flow
Higher risk of floodi
Higher risk of damag
More bad weather

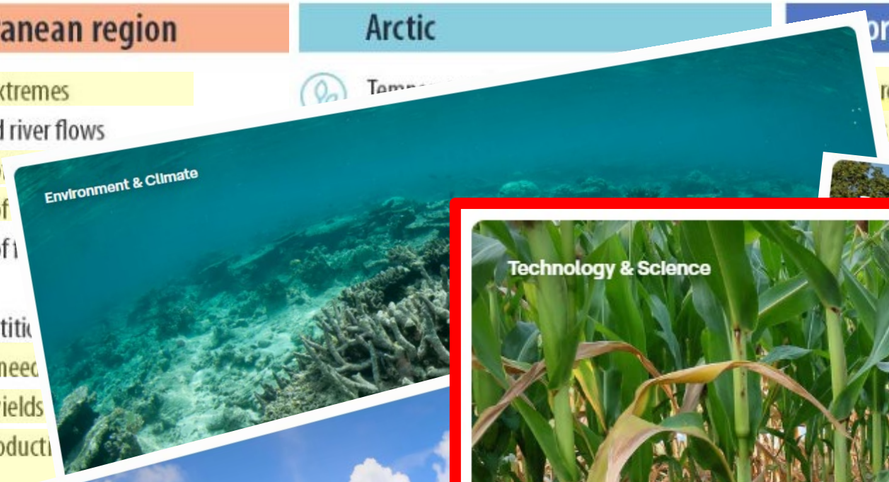
Less energy needed for l

Arctic

Tem

oreal region

re heavy rain
snow and ice
and river flows



A car drives over a place where there used to be a lag

Record dry times in A
planet" wheezing

The exceptional drought tha
largely the result of climate
like this has become 30 times
say.

ganization WHO warns of an
ngue or dengue fever in Europe. The danger
change and the associated rise in temperatures,

Climate change threatens the future of European agriculture

Agriculture and livestock farming will yield less in the future and will even become impossible in some parts of Southern Europe. The European Environment Agency (EEA) writes this in a new report on the consequences of climate change for European agriculture.

One in three tree species is in danger of becoming extinct

CLIMATE CHANGE EFFECTS ON (DAIRY) COWS

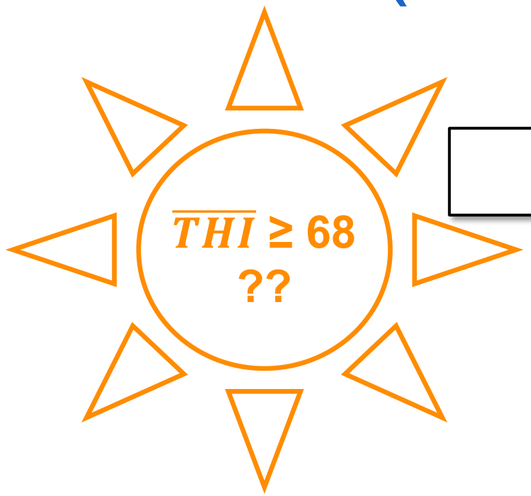
INDIRECT AND DIRECT EFFECTS

Feed, pasture quality

Heat stress – body cannot get rid of excess heat

Impact on:

- Production
- Behaviour
- Welfare



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

Hyperthermia becomes visible via:

- Decreased dry matter & nutrient intake
- Decreased rumen pH (acidosis)
- Altered pathogen and immune responses
- Altered hormone dynamics (thyroid, prolactin, cortisol, progesterone)
- Changed milk composition (reduction in protein yield)
- Impaired oocyte development, conception and maternal effects on calves

CURRENT WEATHER FEATURES

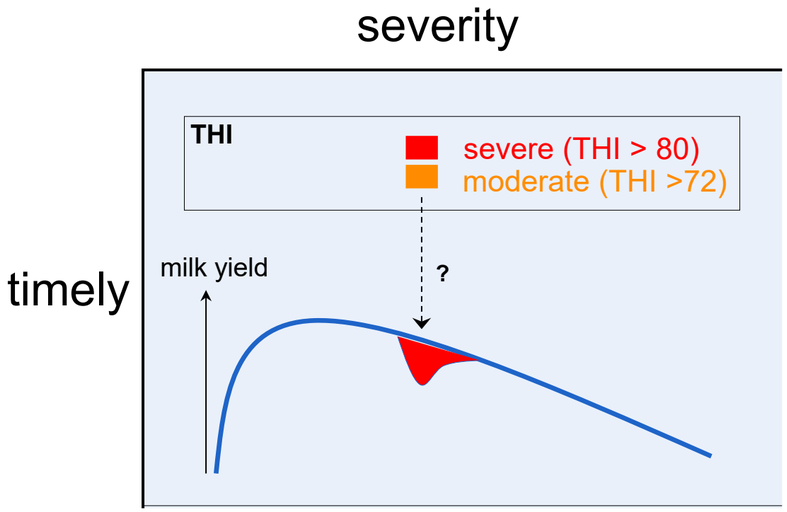
Average THI – classes "mild", "moderate", "severe"

➔ Ignore duration, succession, etc.

GHENT UNIVERSITY

https://www.frontiersin.org/articles/10.3389/fvets.2023.1198697/full

WEATHER FEATURES – TO CONSIDER



Also… first vs. accumulated insults

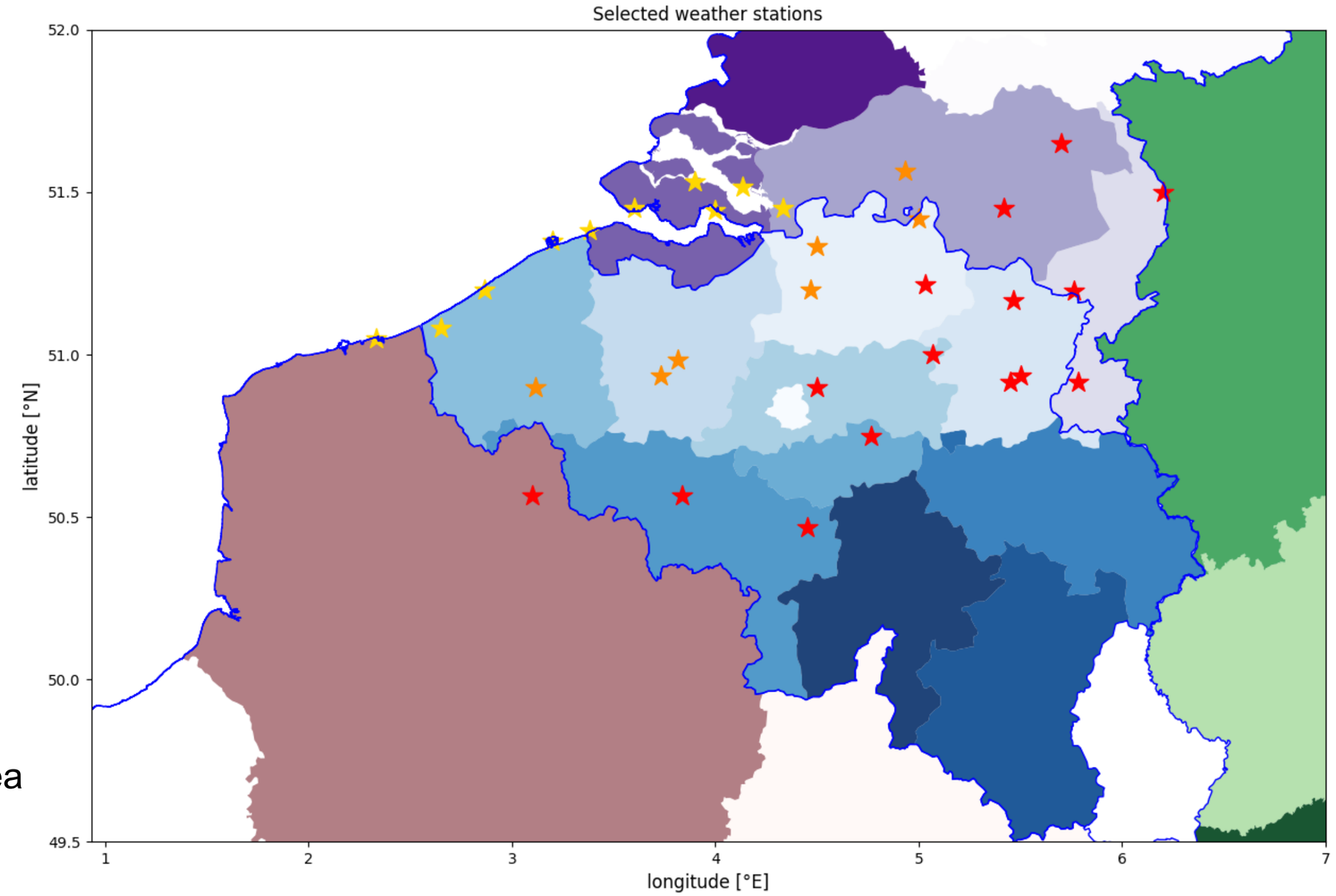
+ indoor vs. outdoor climatic conditions!

DATA

32 weather stations NL-BE-FR
> METEOSTAT
(in neighborhood of farms)

2005 – 2023

Mostly hourly data



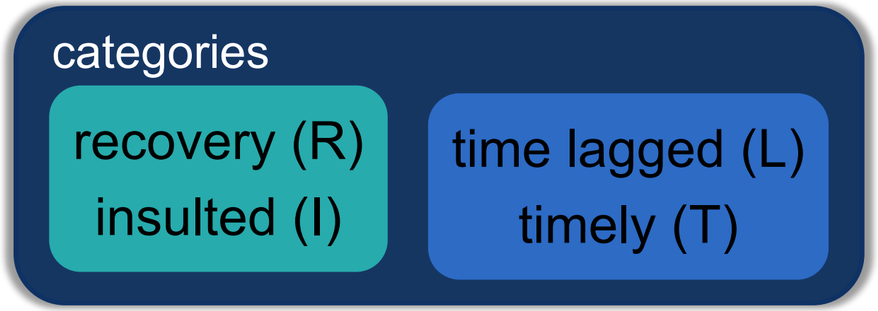
★ inland more than 50 kms from sea

★ coastal between 10 & 50 kms from sea

★ coastal less than 10 kms from sea

GHENT UNIVERSITY

WEATHER FEATURES - EXAMPLES

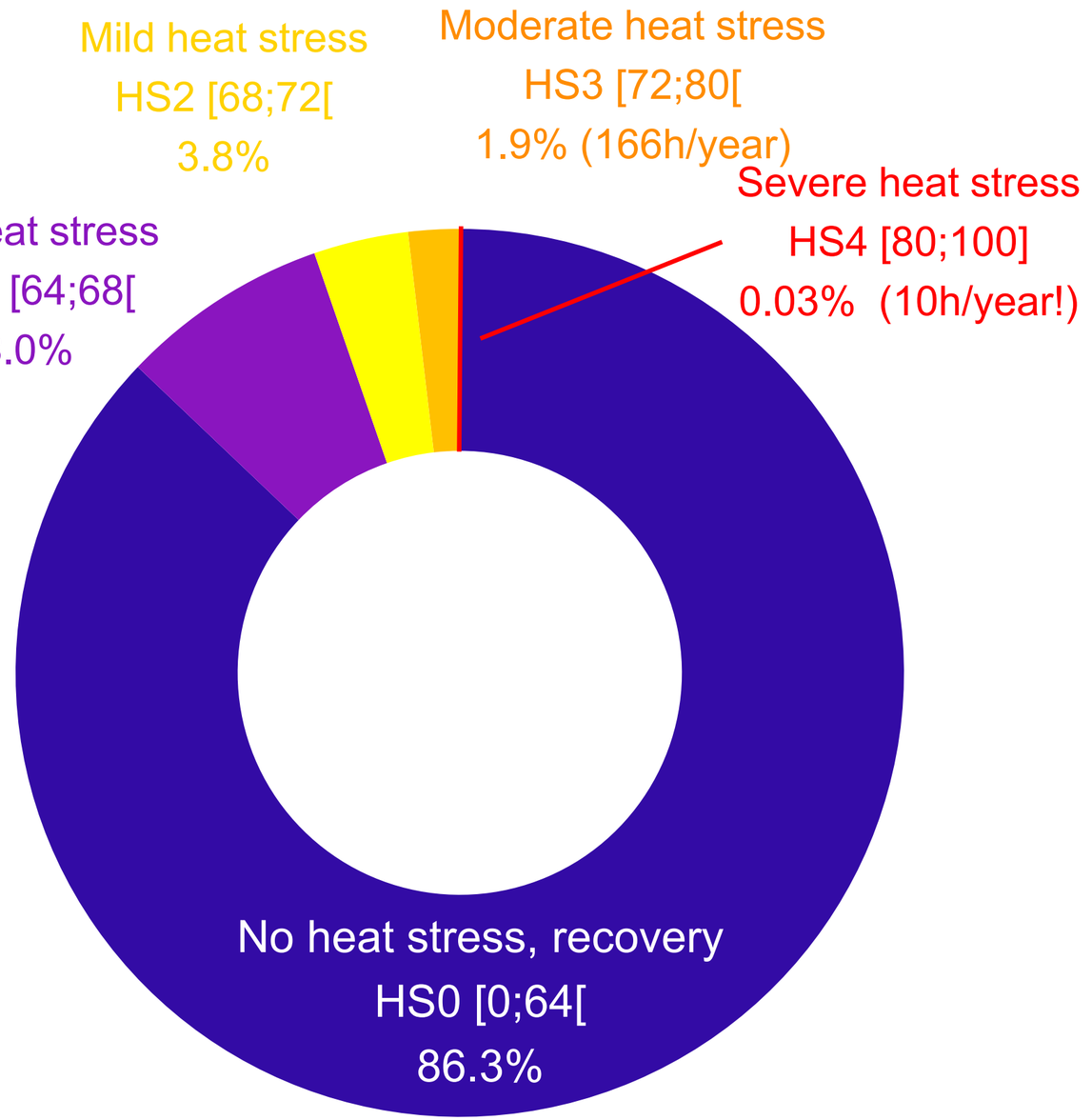


BE-NL-FR dataset

No.	Feature	CAT	Range
1	**Daily maximal THI**	I - T	[23 ; 85]
2	**Daily average THI**	I - T	[14 ; 77]
3	**Number of hours** in each THI class / severity • HS0 “recovery”: THI < 64 • HS1 “no stress”: THI in [64;68[• HS2 “mild stress”: THI in [68 – 72[• HS3 “moderate stress” THI in [72 – 80[• HS4 “severe stress” THI in [80 – 90]	I - T	 [0 ; 24] [0 ; 24] [0 ; 18] [0 ; 19] [0 ; 10]
4	**Total number of hours with THI ≥ 68**	I - T	[0 ; 24]
5	**Lagged heat stress insult**: % of h THI ≥ 68 in d -3 to -1	I - L	[0 ; 69.4]
6	**Recovery effect**: % of h. THI ≤ 64 on days with max THI ≥ 68 on d -3 to -1	R - L	[0 ; 69.5]
7	**Weighted THI insult** (severity considered): e.g. **1***HS2 + **2***HS3 + **4***HS4	I - T	[0 ; 60]

GHENT UNIVERSITY

OVERVIEW WEATHER IN SELECTED DATA [%]



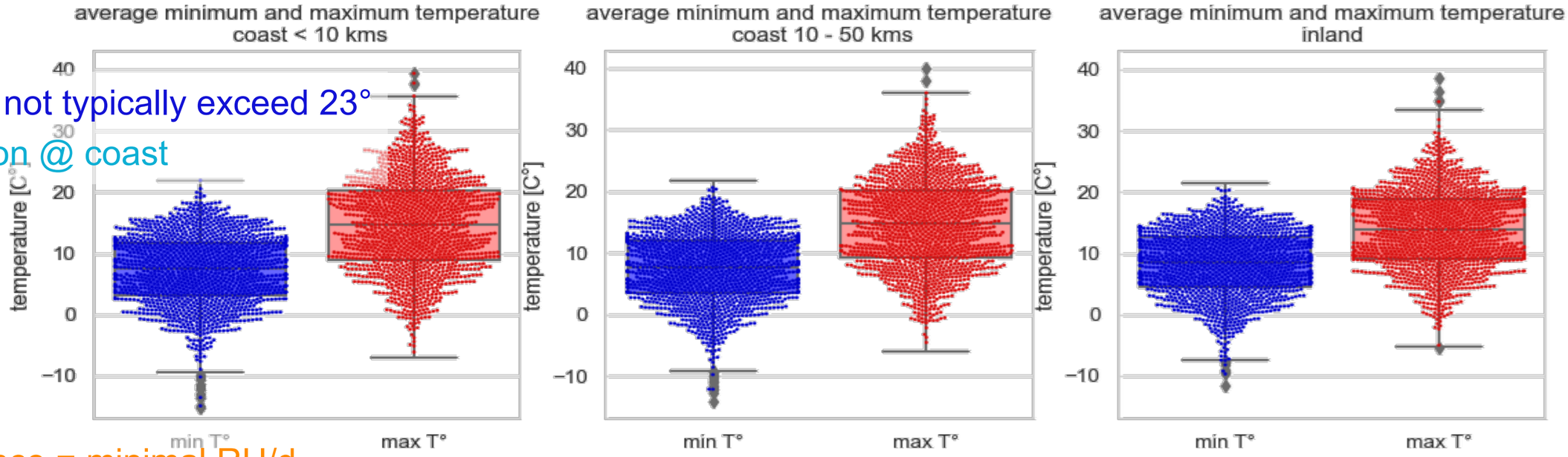
Total 94.3%
No heat stress

GHENT UNIVERSITY

OVERVIEW WEATHER IN SELECTED DATA

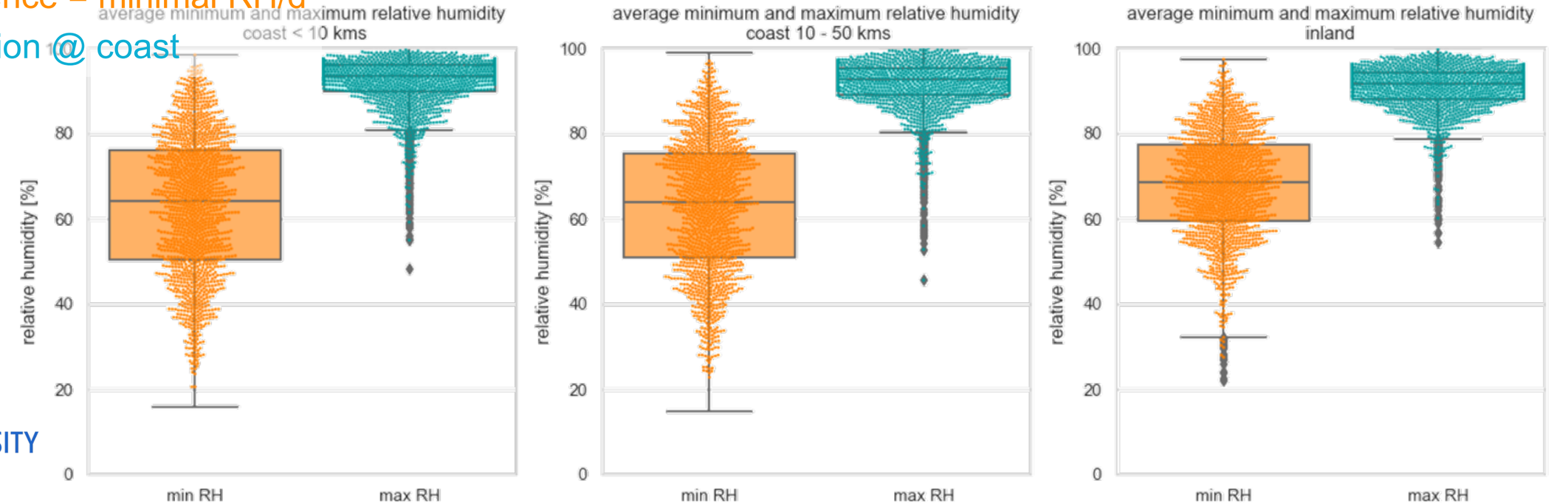
Min T° does not typically exceed 23°

More variation @ coast



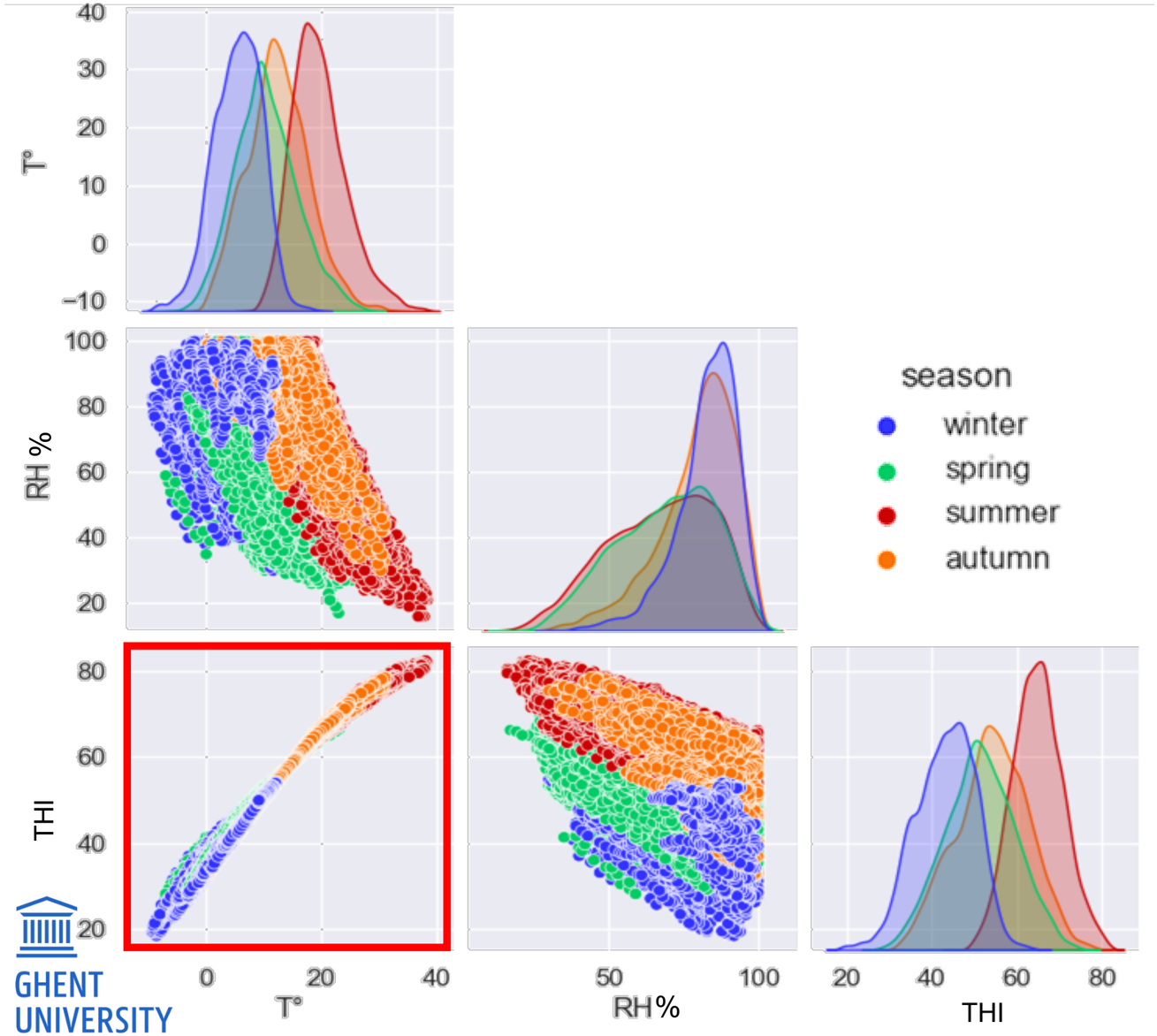
Main difference = minimal RH/d

More variation @ coast

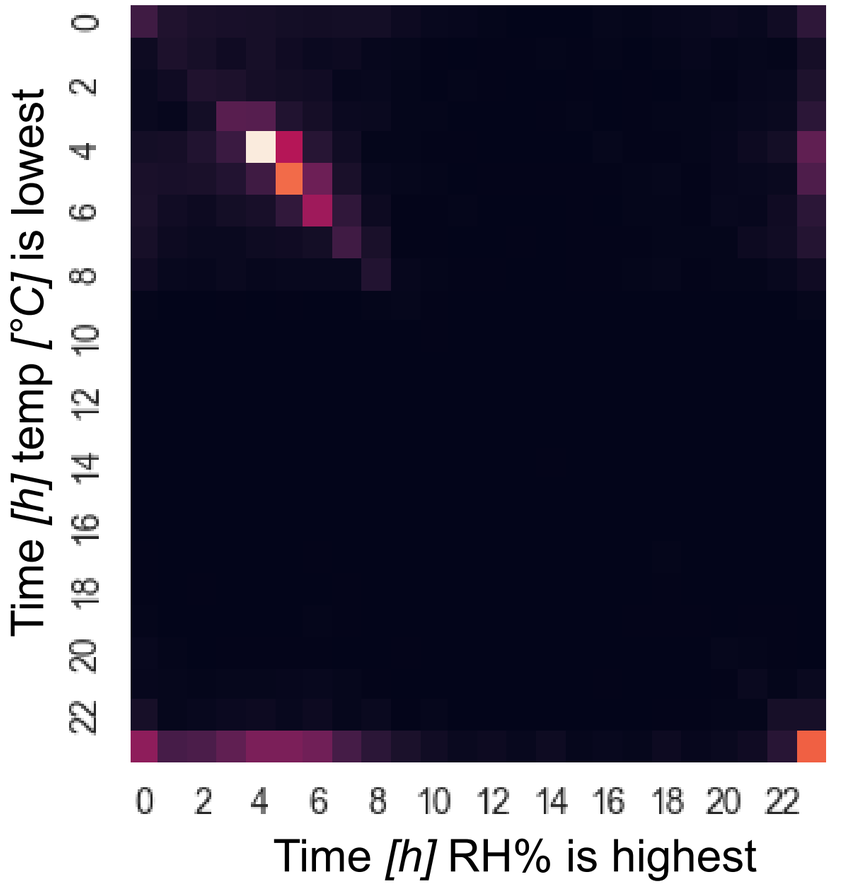


GHENT UNIVERSITY

OVERVIEW WEATHER IN SELECTED DATA

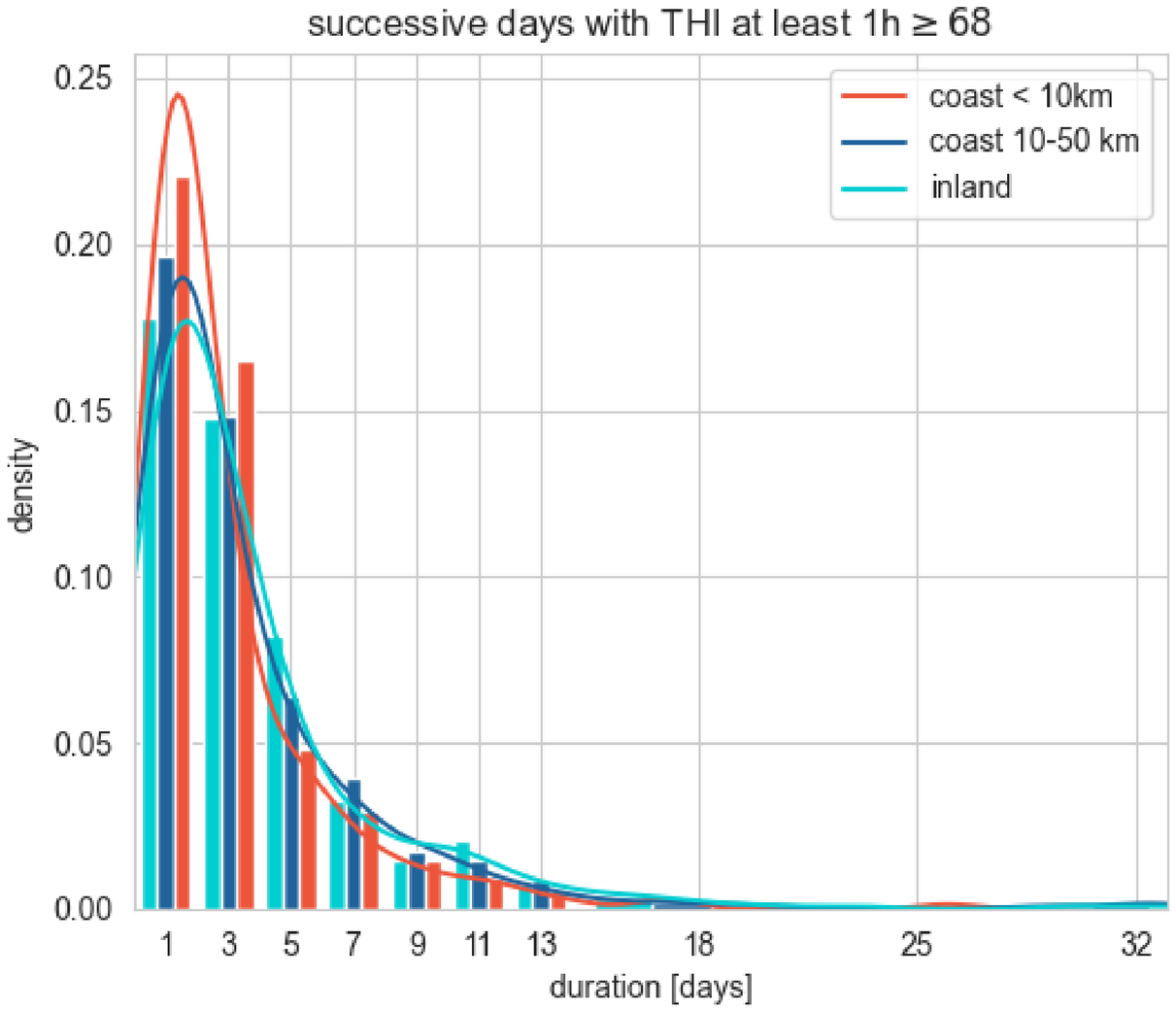


Frequency plot max RH, min T°



GHENT UNIVERSITY

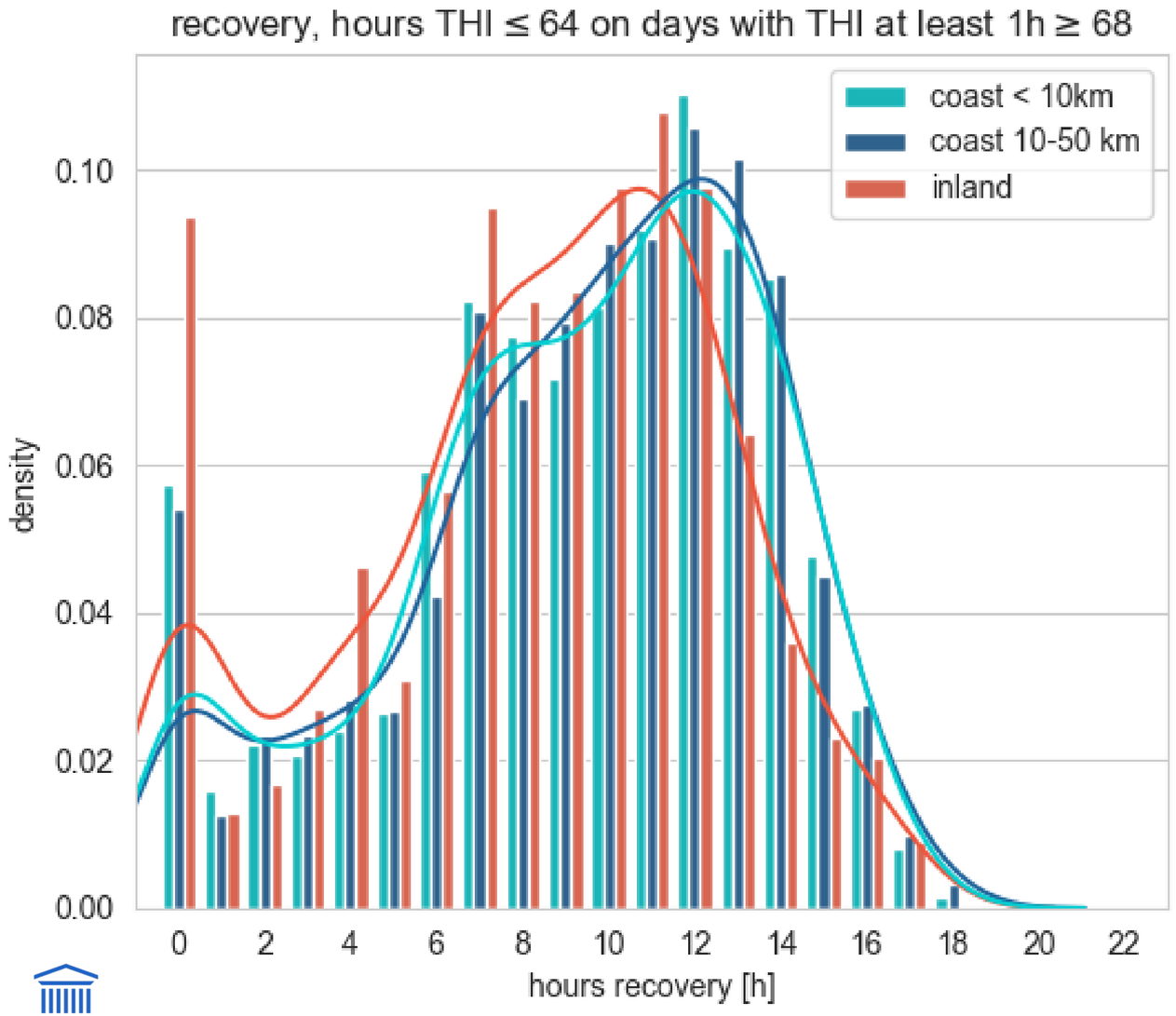
OVERVIEW WEATHER IN SELECTED DATA – DURATION



Successive days in which THI is at least 1h ≥ 68

- 20% THI “insult” lasts only one or two days
- in 15% of the time, 5 or more days

OVERVIEW WEATHER IN BE-NL - RECOVERY



% of days with no recovery (0h with THI < 64):

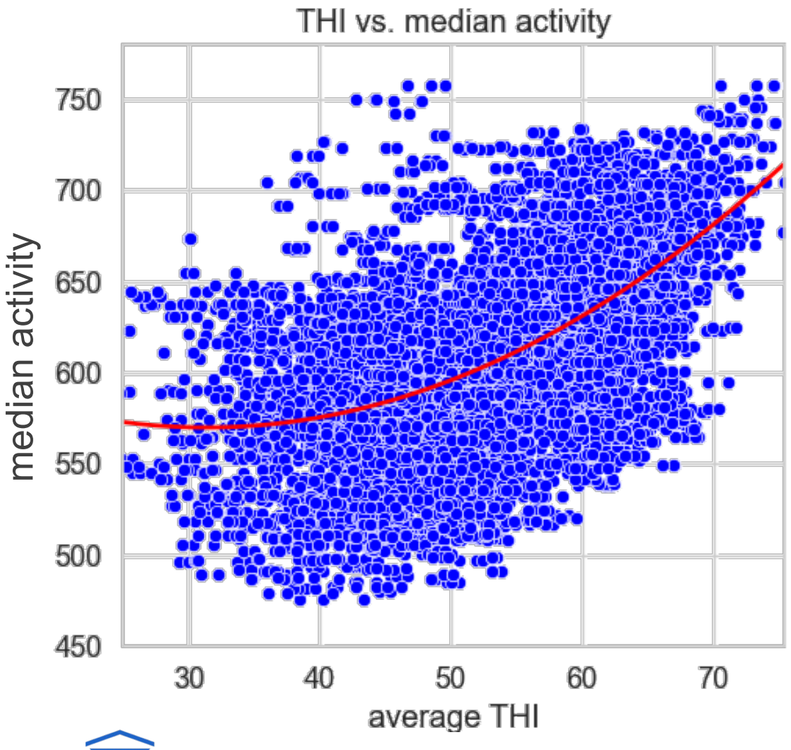
- coast < 10km: 5.74%
- coast 10-50 km: 5.41%
- inland: 9.37%

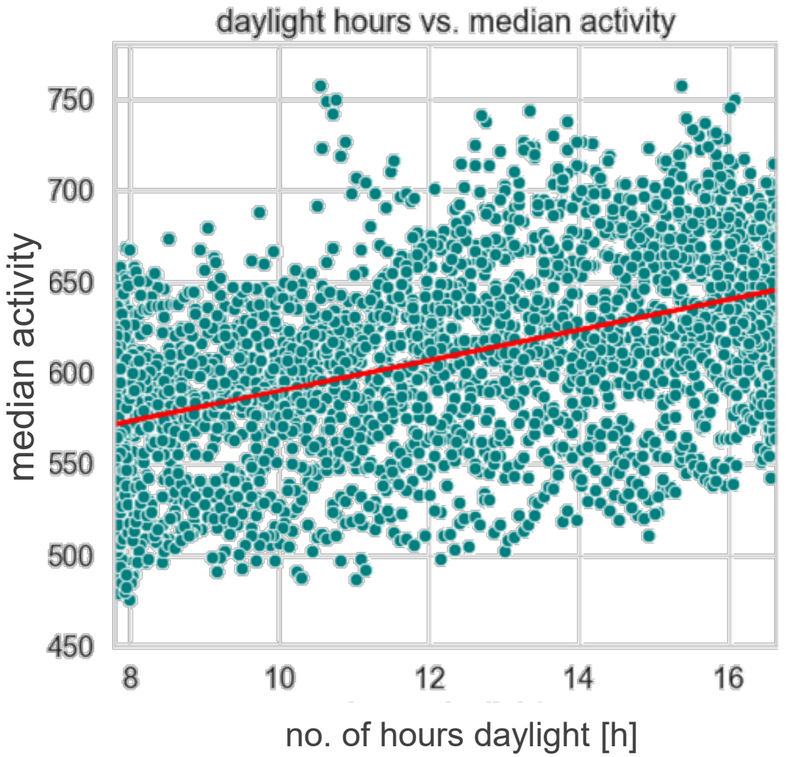
Weather within one day a bit more variable at the coast

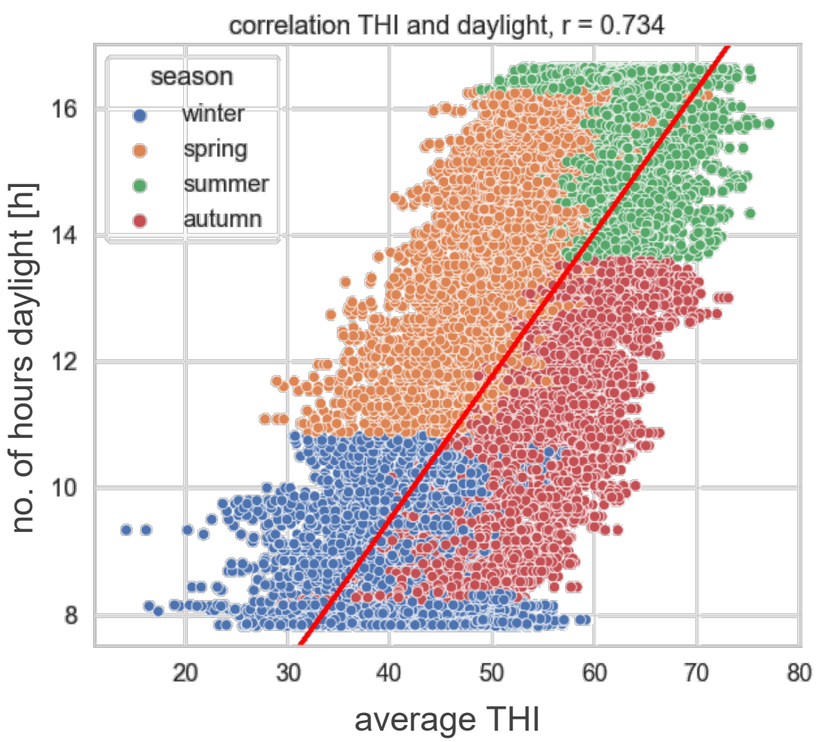
GHENT UNIVERSITY

CONFOUNDING EFFECTS

Activity (step count) in function of THI







GHENT UNIVERSITY

TAKE HOME

- Climate and weather is more than average THI –
  - Consider timely/time-lagged, duration, severity, succession of insults
  - Knowledge of indoor vs outdoor climate and heat mitigation measures might be necessary
  - Define weather features based on effect you want to study
  - Careful with confounding/correlated effects such as daylight-temperature
  - Also consider the confounding factors on the animals for which they are more sensitive to weather changes
    (e.g. health status, genetic difference, parity, etc.)
- Severe heat stress in Belgium and the Netherlands is rare
- Moderate heat stress might already have impact, but more research is needed
- Indirect effects of climate change might be more pronounced (drought, rain)