ARCADIS | Design & Consultancy for natural and built assets

Temperature in nests of Swifts under tiled roofs reviewed

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Int. Swift Conference, Castlebar, Ireland, 2026

Corrected version 20260620

Why this review

- High temperatures under roofs are known for quite some time (Moermans, Hoekstra, Schröder, all NL)
- However, ‘swift-tiles’ are still used in some mitigation projects
  - E.g. NCG, Groningen, NL by a.o. Arcadis
- Working for Arcadis, I questioned this way of mitigation
  - Is it successful? Are there any swifts breeding under the tiles? Are the young fledging succesfully?
  - No answers
- 1st reaction: Let us do some more research (typical Dutch)

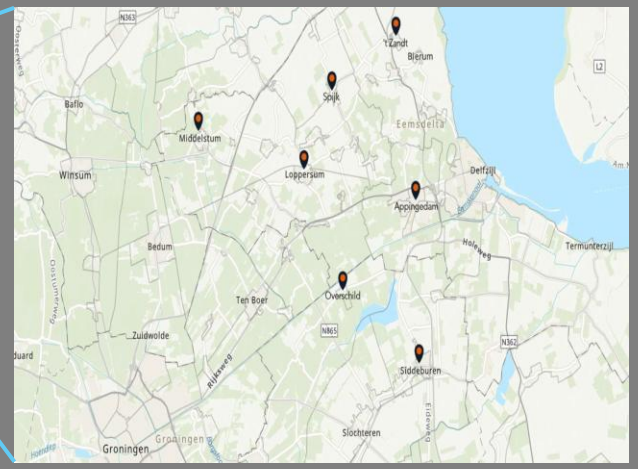
NCG: Species Management Plan

- 1 general license to rebuild en re-inforce buildings that are damaged by earthquakes due to gas extraction (NE NL)
- Regular: 3 nests for every nest that disappears
- SMP: All houses will become nature-inclusive
  - ≥ 1 Swift nest facility, and/or
  - ≥ 1 House sparrow nest facility, and/or
  - ≥ 1 bat roosting / colony facility
- General idea: Swifts nesting places will disappear, but more new and suitable nest facilities will return

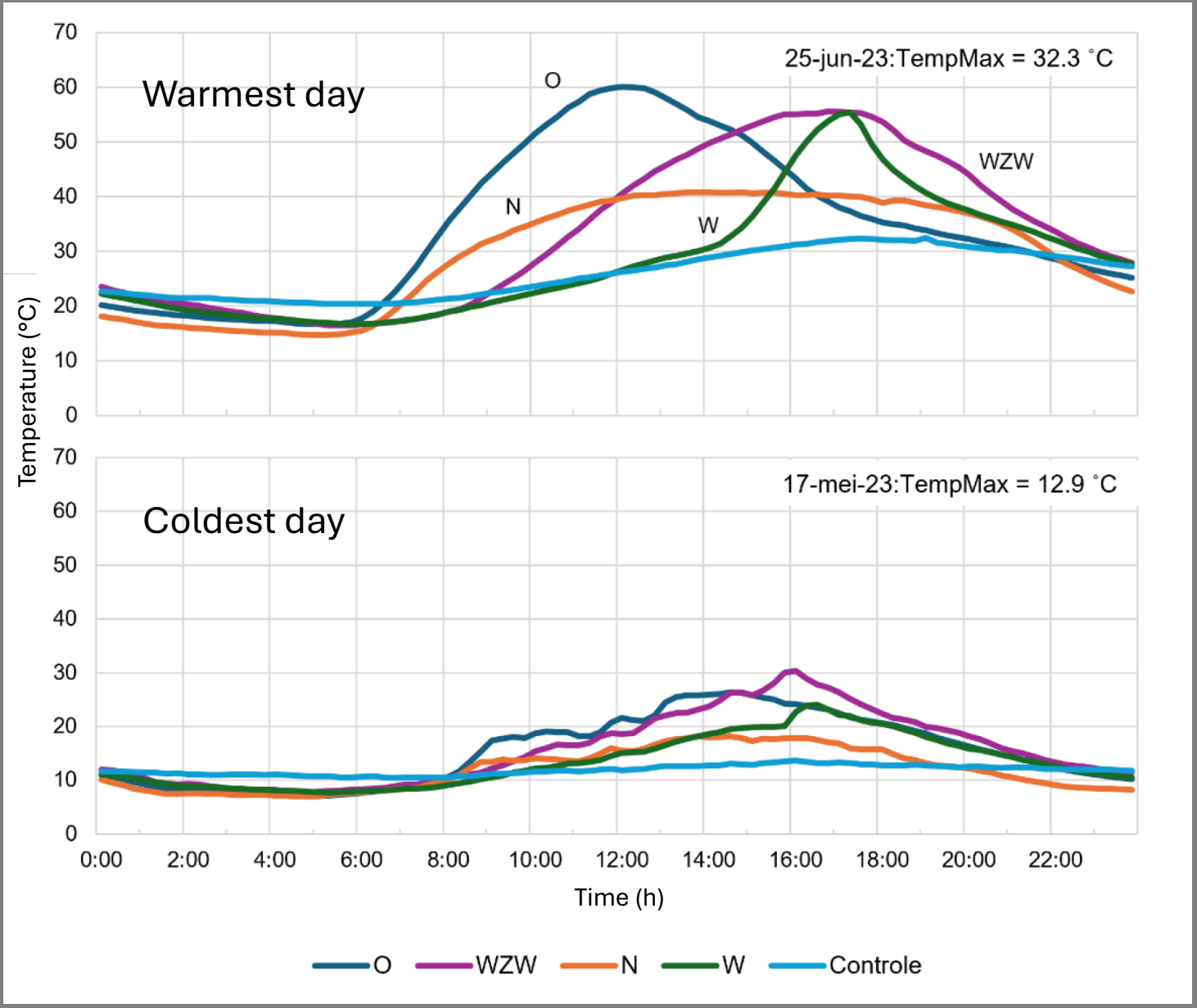
- But if they are not suitable → new measures (expensive)

Temperature measurements NCG

- Student Elja Schalks (2024-2025)
  - Arcadis, supervisors Maartje Rams & Rick Wortelboer
  - Wageningen University, supervisor Hugo Loning
- Temperature loggers were placed
  - 2023: 23
  - 2024: 28
  - 29 addresses
  - 1-5 loggers per address
    - Different sides of roof
    - Duplo
    - Different heights



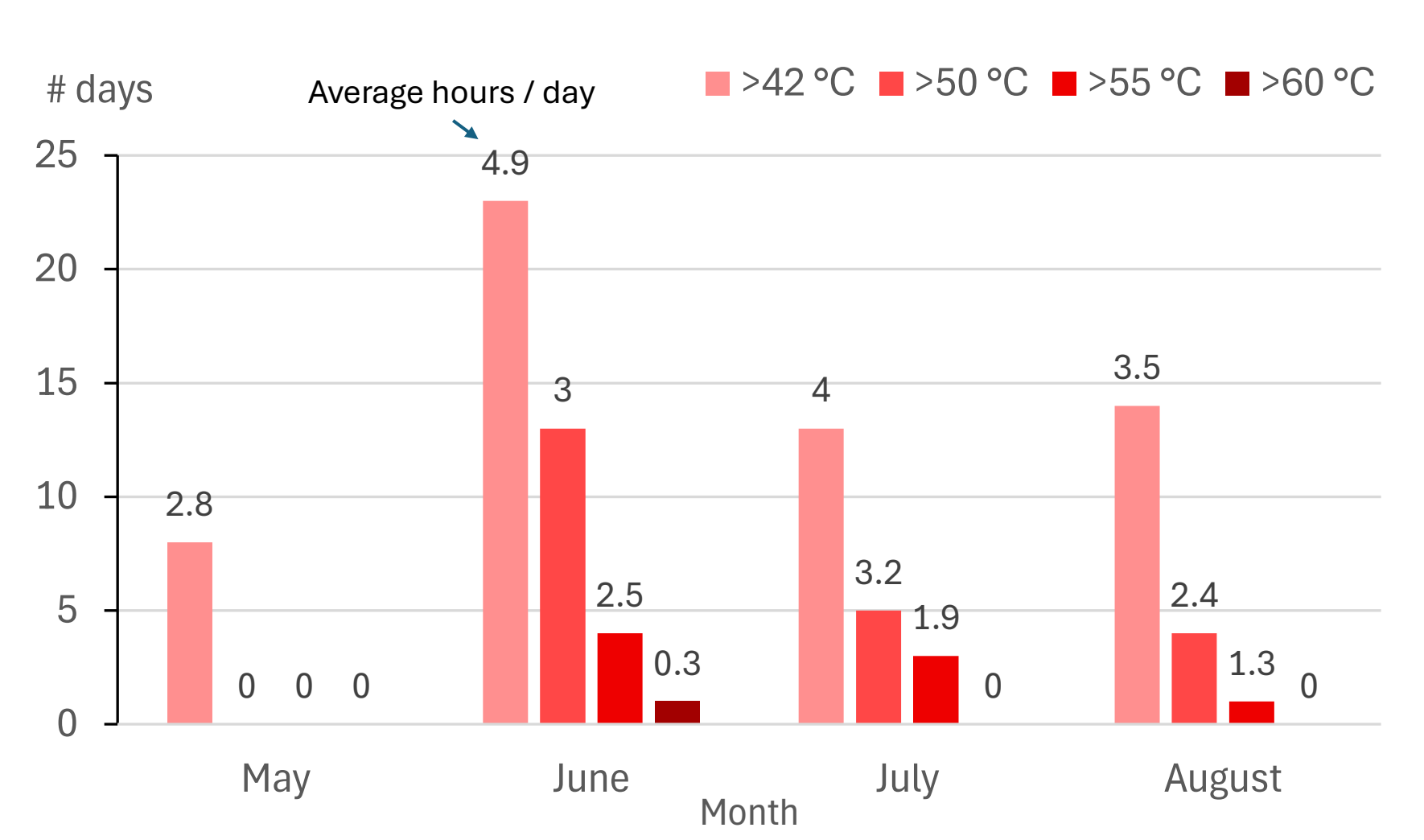
Results



- Highest temperature under roof on warmest day (32 °C outside): 60 °C (East) or 56 °C (West)
- Highest temperature under roof on coldest day (13 °C outside): 26 °C (East) or 30 °C (WSW)
- Temperature difference with outside air temperature max. 34 °C (East) and 21 °C (WSW)
- No measurements on south facing roofs

Data: Logger 3a

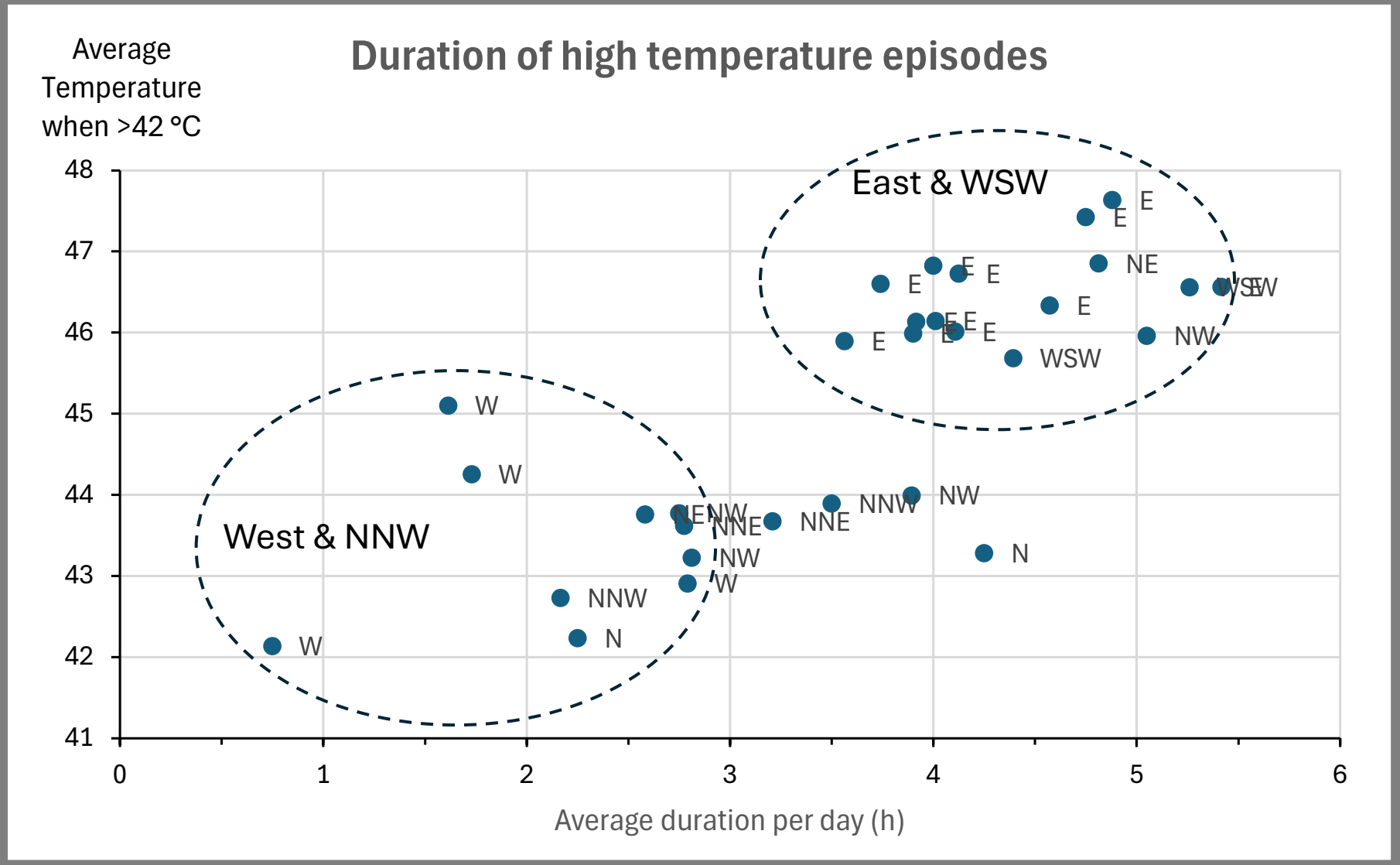
Duration of measured high maximum temperature episodes under roofs



- Extended periods with high tempertures measured
- What is the maximum duration a young can survive?

Data: Logger 3a

All expositions show high maximum temperatures



- Highest temperatures and longest episodes in East & WSW
- Lowest and shortest in West & NNW
- Exposition can't explain all differences

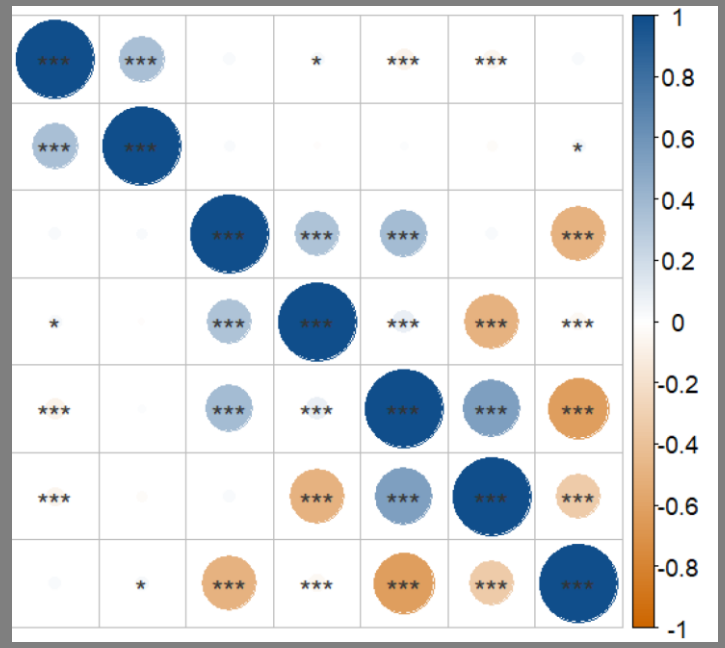
Data: all loggers

Modelling daily maximum temperatures

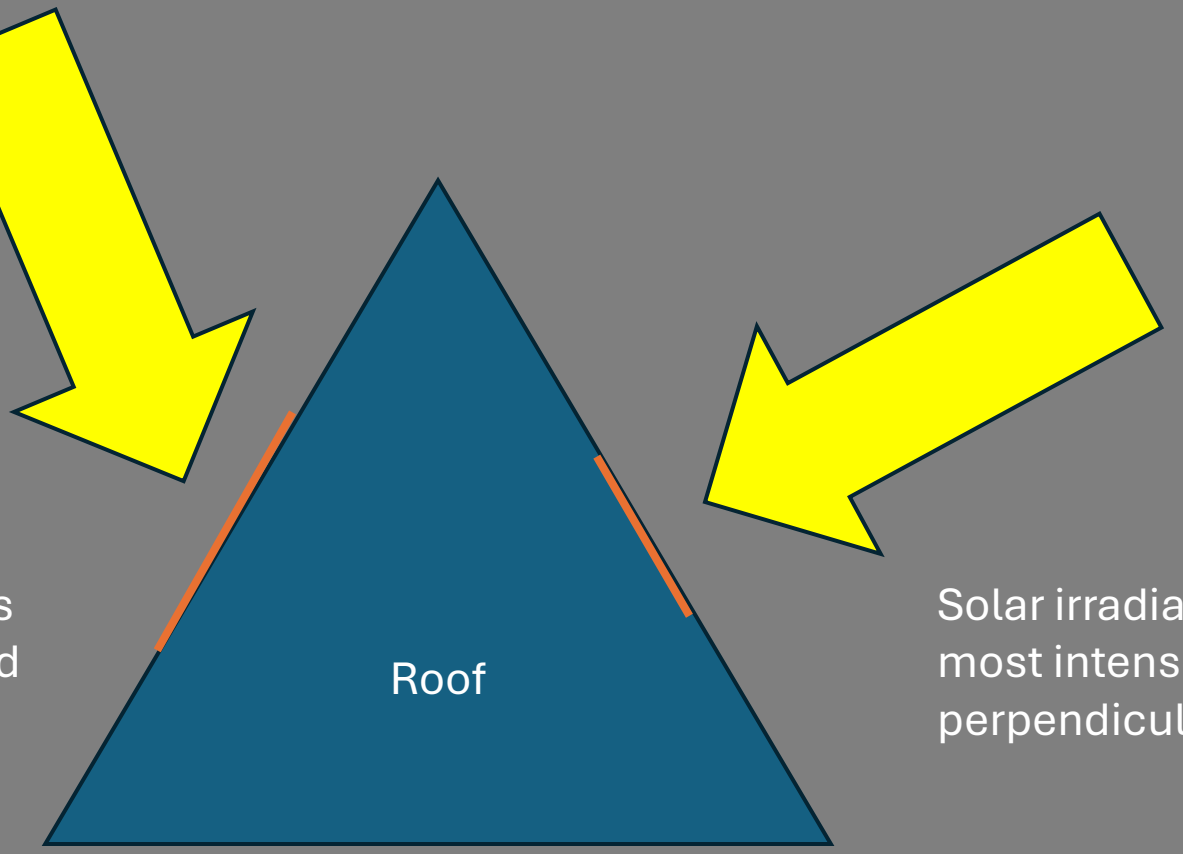
- Target variable: measured daily maximum temperature under roof (°C)
- Explaining variables:
  - Daily total solar irradiation (J/m2)
  - Daily maximum outdoor temperature (°C, in shade)
  - Roof exposition (wind direction, difference with south; 0-180°)
  - Roof slope: between 0° (horizontal) and 90° (vertical)
  - Tile material (clay / concrete)
  - Tile colour (red / black)
  - Tile glazing (with / without)
  - Relative height on roof (0-1)

Modelling daily maximum temperatures

- However: correlations within the construction variables
  - E.g. all glazed tiles were red tiles
  - All concrete tiles were black
- Therefor model restricted to:
  - Daily total solar irradiation (J/m2)
  - Daily maximum outdoor temperature (°C, in shade)
  - Roof exposition & Roof slope, combined into → Exposition-Slope-Index ESI)
  - Tile colour (red / black)
  - Tile Material (ceramic / concrete)
  - Placement on the roof (low / high)



Intensity of solar irradiance dependent on slope of roof



Solar irradiation less intense when spread out over roof

Solar irradiation most intense when perpendicular to roof

Combining exposure and roof slope into Relative Irradiance Intensty (Exposure-Slope-Index)

Exposure / Wind direction

South

North

Roof slope (°)	N	NNW	NW	WNW	W	WSW	SW	SSW	S	SSE	SE	ESE	E	ENE	NE	NNE	N
90	0	0	0	0	0	0.16	0.32	0.42	0.48	0.42	0.32	0.16	0	0	0	0	0
85	0	0	0	0	0.08	0.24	0.39	0.5	0.55	0.5	0.39	0.24	0.08	0	0	0	0
80	0	0	0	0.08	0.15	0.31	0.47	0.57	0.62	0.57	0.47	0.31	0.15	0.08	0	0	0
75	0	0	0.11	0.17	0.23	0.38	0.53	0.64	0.69	0.64	0.53	0.38	0.23	0.15	0.08	0	0
70	0	0	0.15	0.23	0.3	0.45	0.6	0.7	0.75	0.7	0.6	0.45	0.3	0.2	0.1	0	0
65	0	0.09	0.19	0.28	0.37	0.52	0.66	0.76	0.8	0.76	0.66	0.52	0.37	0.28	0.19	0.09	0
60	0.03	0.13	0.23	0.34	0.44	0.58	0.71	0.81	0.85	0.81	0.71	0.58	0.44	0.34	0.23	0.13	0.03
55	0.11	0.21	0.31	0.41	0.5	0.63	0.76	0.85	0.89	0.85	0.76	0.63	0.5	0.41	0.31	0.21	0.11
50	0.2	0.29	0.38	0.47	0.56	0.69	0.81	0.89	0.93	0.89	0.81	0.69	0.56	0.47	0.38	0.29	0.2
45	0.28	0.37	0.45	0.54	0.62	0.73	0.85	0.92	0.96	0.92	0.85	0.73	0.62	0.54	0.45	0.37	0.28
40	0.37	0.44	0.52	0.6	0.67	0.78	0.88	0.95	0.98	0.95	0.88	0.78	0.67	0.6	0.52	0.44	0.37
35	0.45	0.51	0.58	0.65	0.72	0.81	0.9	0.96	0.99	0.96	0.9	0.81	0.72	0.65	0.58	0.51	0.45
30	0.52	0.58	0.64	0.7	0.76	0.84	0.92	0.97	1	0.97	0.92	0.84	0.76	0.7	0.64	0.58	0.52
25	0.59	0.65	0.7	0.75	0.8	0.86	0.93	0.98	1	0.98	0.93	0.86	0.8	0.75	0.7	0.65	0.59
20	0.66	0.7	0.74	0.79	0.83	0.88	0.93	0.97	0.99	0.97	0.93	0.88	0.83	0.79	0.74	0.7	0.66
15	0.73	0.76	0.79	0.82	0.85	0.89	0.93	0.96	0.97	0.96	0.93	0.89	0.85	0.82	0.79	0.76	0.73
10	0.78	0.8	0.82	0.84	0.87	0.89	0.92	0.94	0.95	0.94	0.92	0.89	0.87	0.84	0.82	0.8	0.78
5	0.83	0.84	0.85	0.87	0.88	0.89	0.9	0.91	0.92	0.91	0.9	0.89	0.88	0.87	0.85	0.84	0.83
0	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88

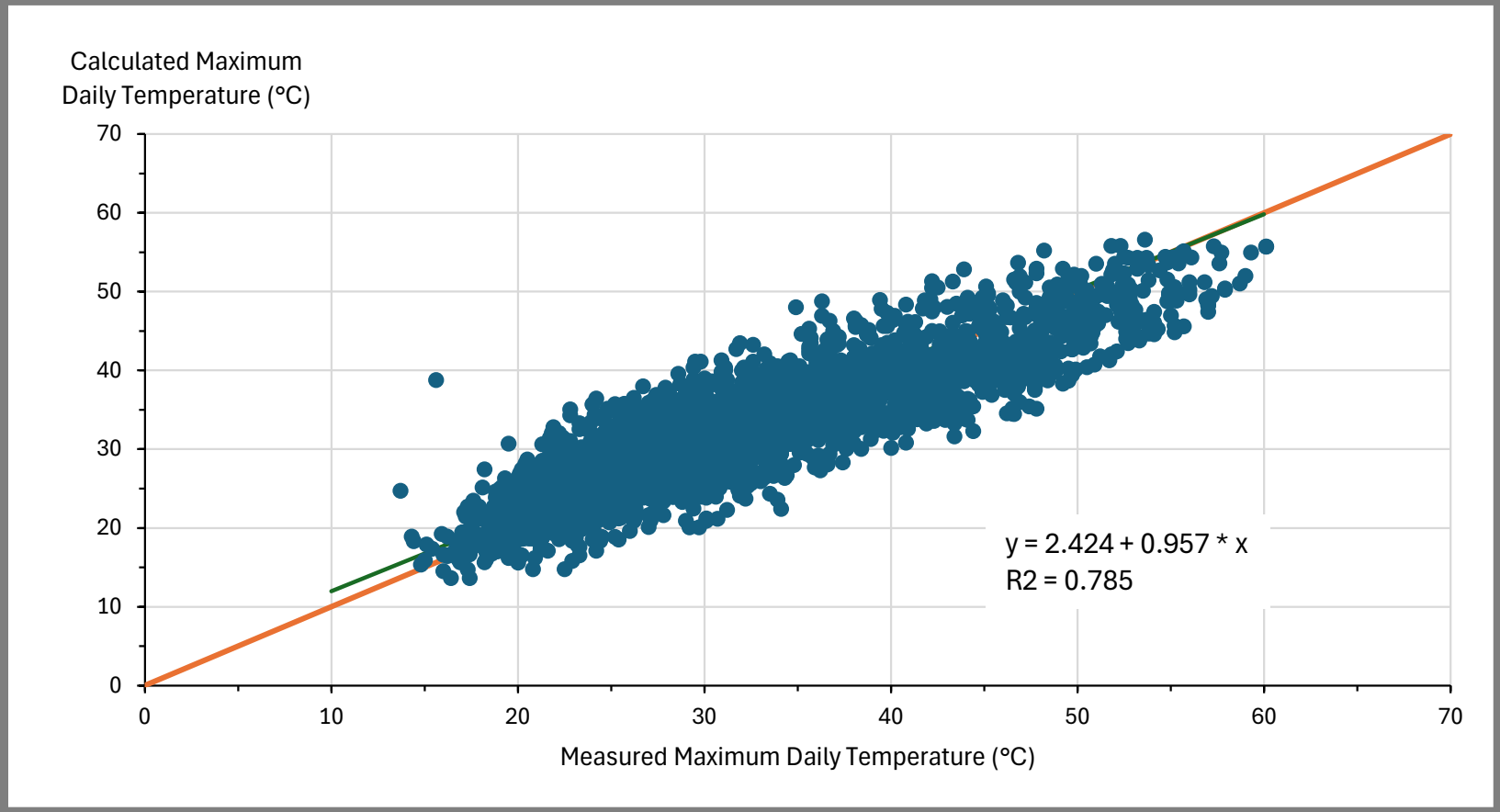
Vertical

Horizontal

June 21, Noon
52° N, 5° E

Comparison of measured and calculated maximum temperatures under tiled roofs

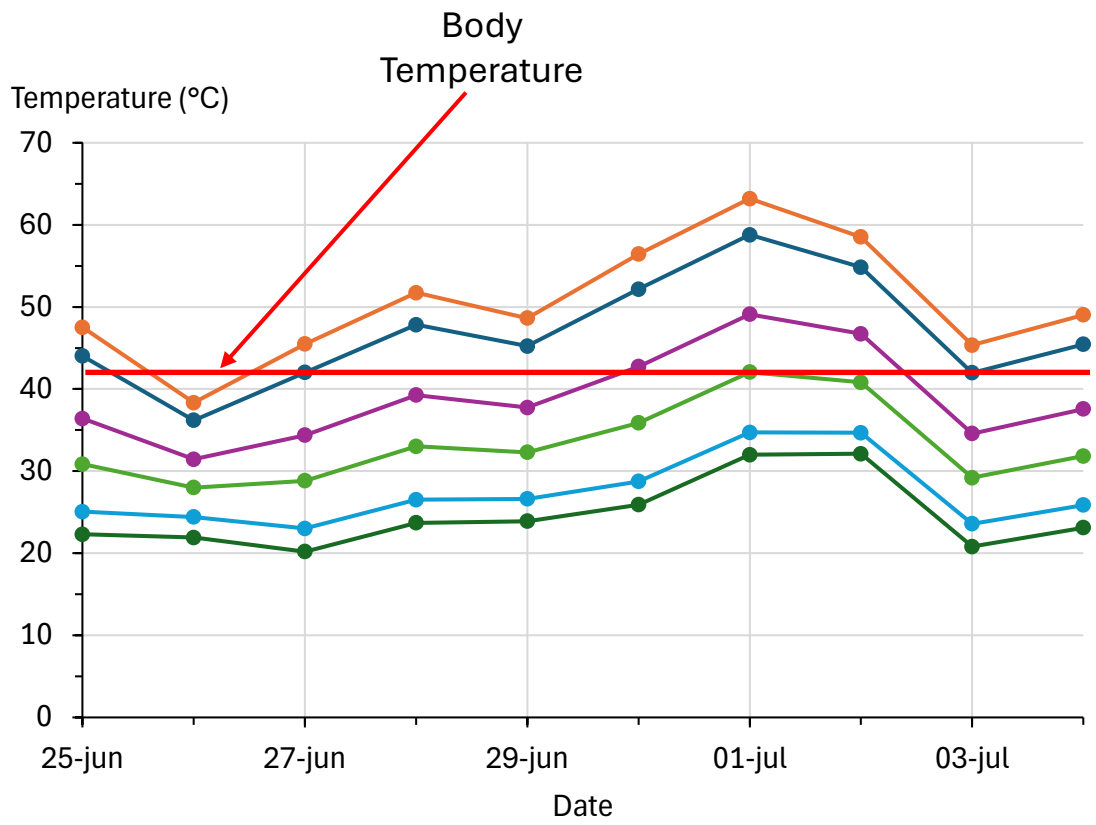
- Model fitted on data of 2023
- 78% of variation in daily maximum temperatures explained by model



Model
Tmax, roof = -2.651
+0.977 * MaxTempOutside
+ 0.007 * Irradiance
+ 0.00009 * MaxTempOutside*Irradiation
+ 0.17 * TileColour
+ 6.5 * TileMaterial
+ 3.8 * RelativeHeightOnRoof

Estimating maximum roof temperature during heat spell 2025

Model application under various types of roofs

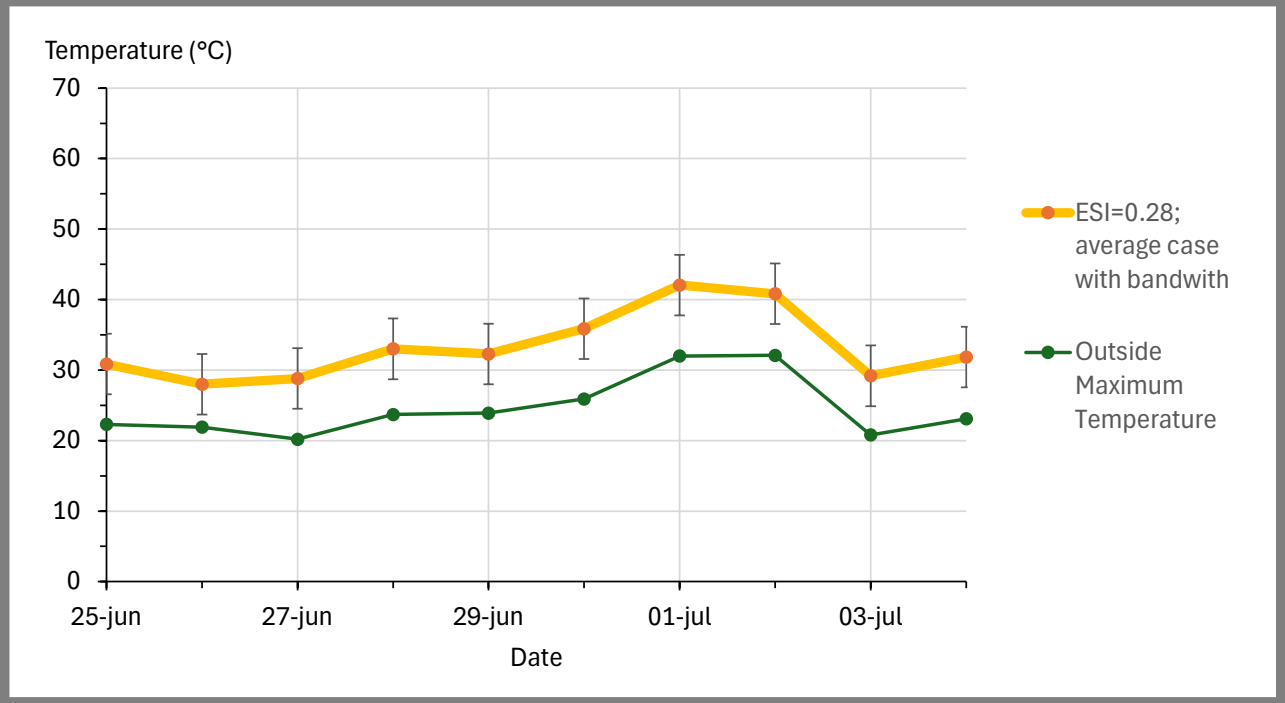


		Slope of Roof	Exposition-Slope-Index
South, 30°	South	30 °C	1.00
South, 60°		60 °C	0.85
North, 30°	North	30 °C	0.52
North, 45°		45 °C	0.28
North, 60°		60 °C	0.03
Outside Temperature	Outdoor Temperature		

Estimating daily maximum roof temperature during heat spell 2025

Model application

- Because of the setup with the Exposition-Slope-Index, all situations where ESI=0.28 gives maximum temperature of 42 °C under the ‘average’ tiled roof with extreme conditions of irradiation and outside temperature of 1st July in Groningen, NL.
- Total bandwith of 8.6 °C caused by influence of:
  - colour of tiles (±0.085 °C; red: low values, black: high values)
  - tile material (±3.25 °C; ceramic: low values, concrete: high values), and
  - location on the roof (±0.95 °C; low: low values; high: high values)



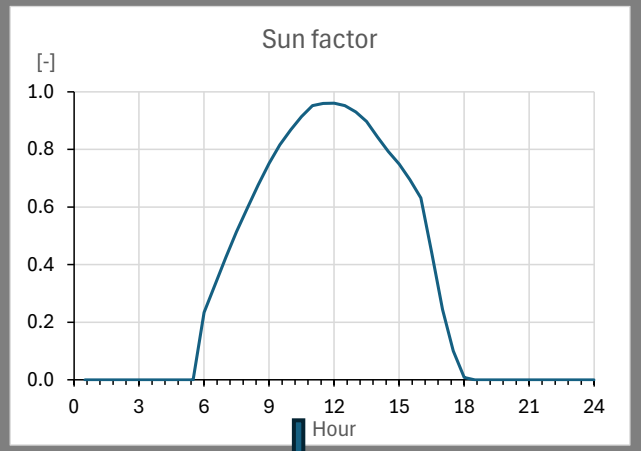
ESI = 0.28:

- North, 45°
- NW, 57°
- W, 72°
- SW: -
- S: -
- SE: -
- E: 72°
- NE: 57°

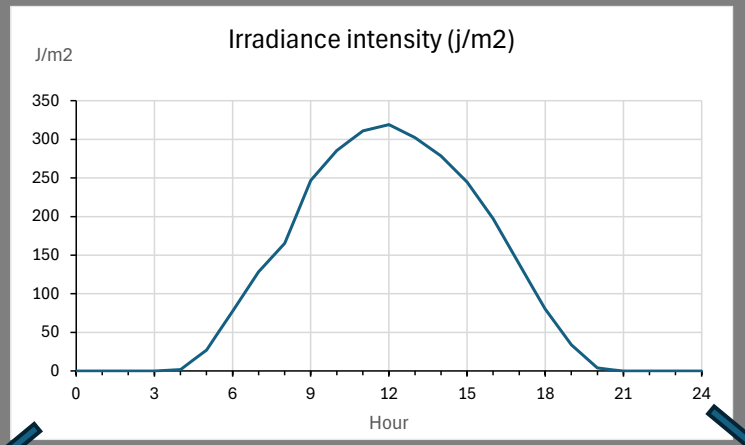
Dynamic modelling of temperature during the day

Using Exposure-Slope-Indextor, for each roof (exposure, slope) temperature under roof can be calculated (using some assumptions): do we understand what is going on?

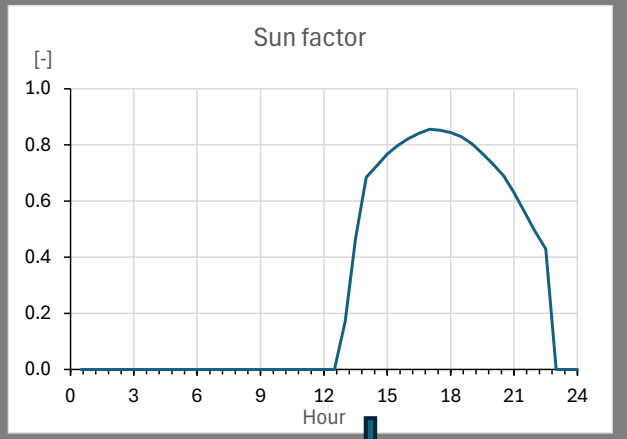
East (110 °; slope: 60°)

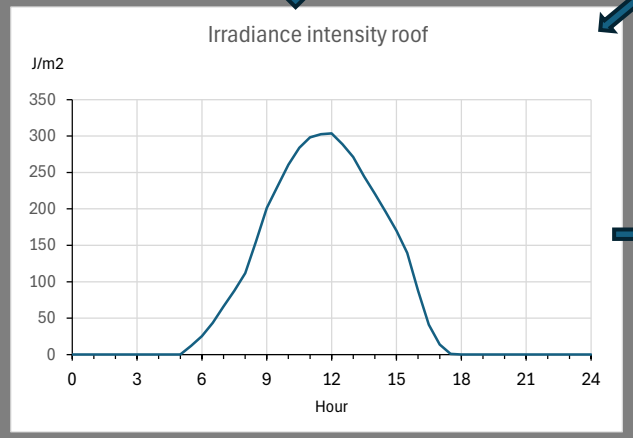


Measured Irradiance

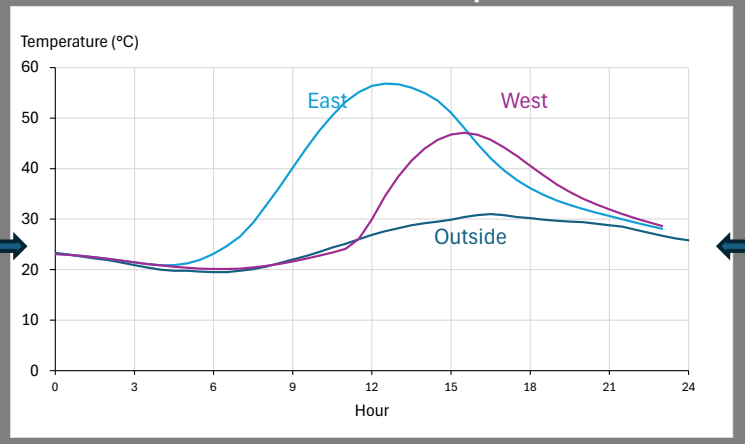


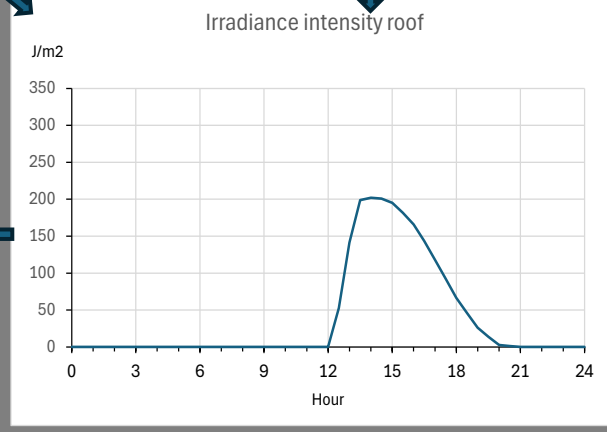
West (290 °; slope: 60°)



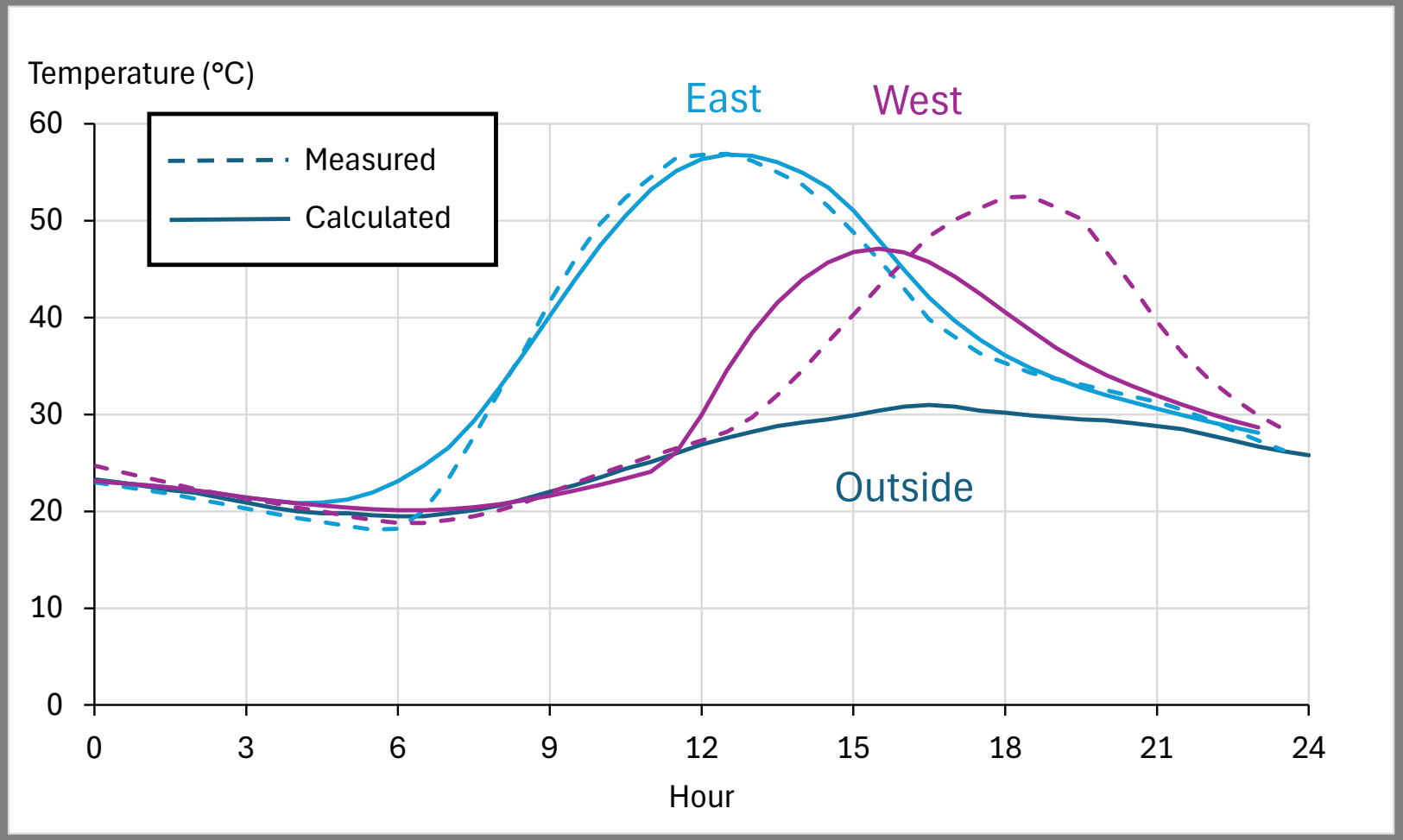


Calculated temperature





Simulating temperature under roofs



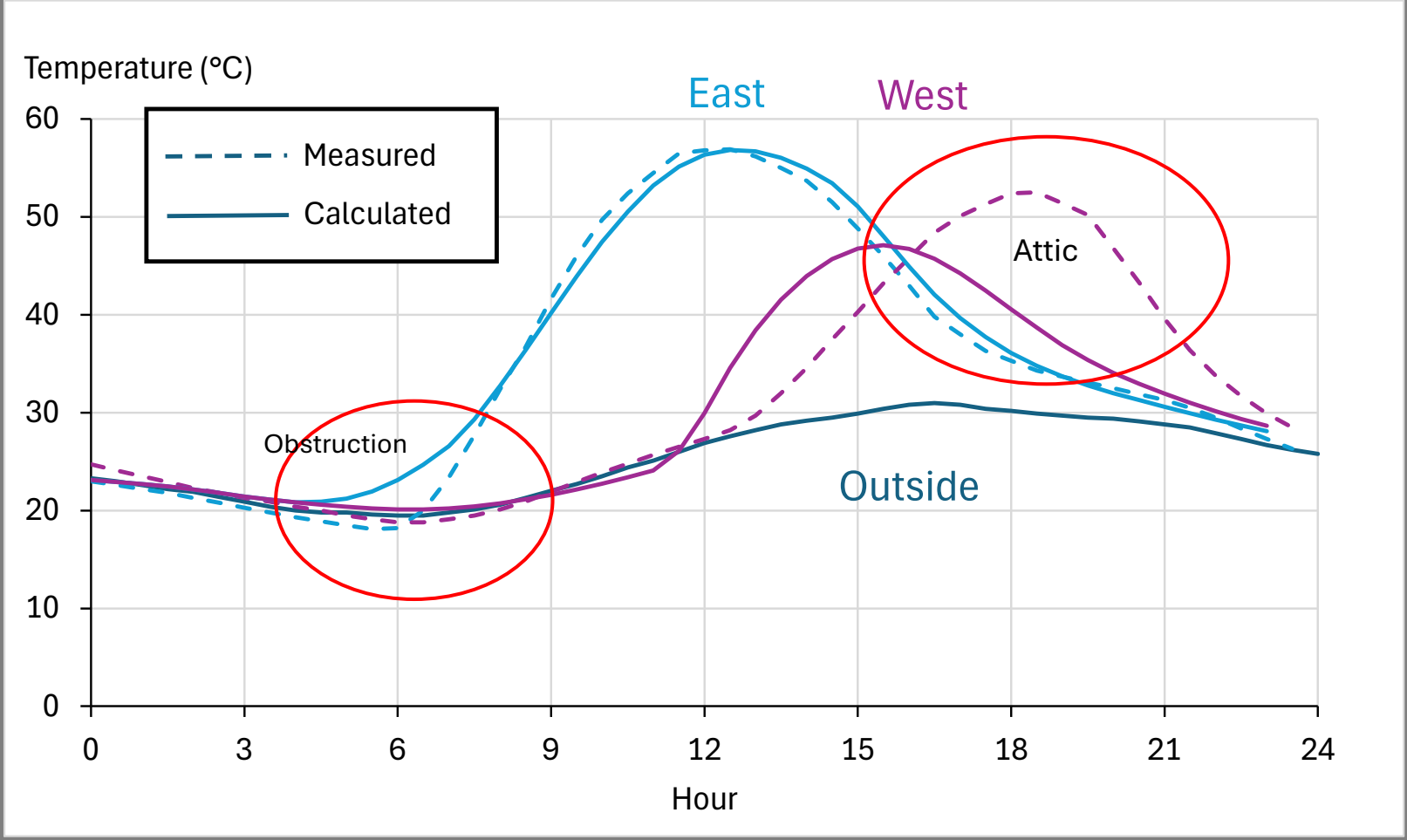
- General simple model, including
  - Heating by sun
  - Cooling to outside air temperature

Model
Tt = T(t-1)
+ 0.244 * Irradiance
- 0.2 * (T(t-1) – TempOutside)

Data: Henk Schröder (2024)

Date: 25 June 2023

Simulating temperature under roofs



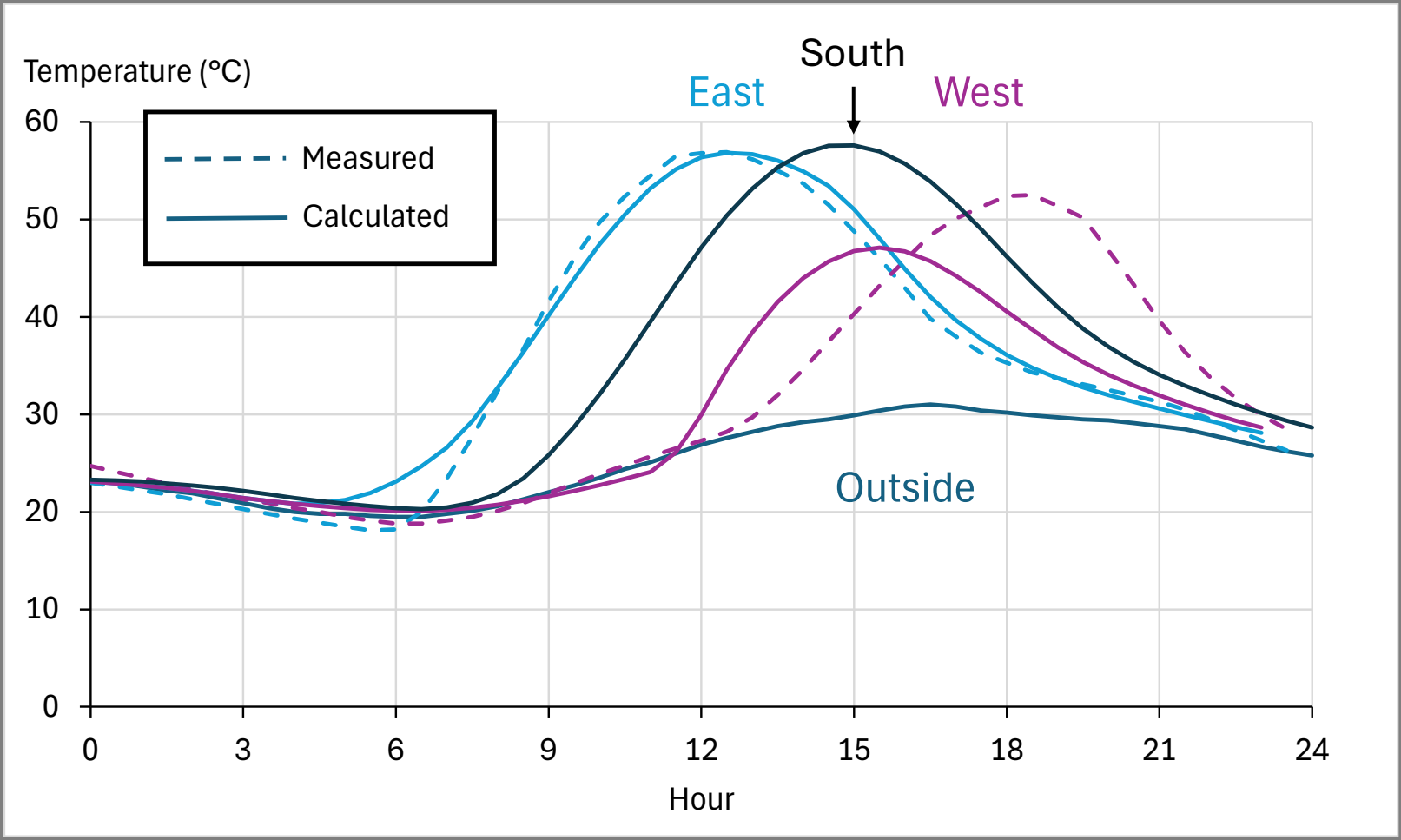
- General simple model, including
  - Heating by sun
  - Cooling to outside air temperature
- Not included:
  - Obstruction by other objects (neighbours' house and trees)
  - Heating of construction (attic)

Model
Tt = T(t-1)
+ 0.244 * Irradiance
- 0.2 * (T(t-1) – TempOutside)

Data: Henk Schröder (2024)

Date: 25 June 2023

Simulating temperature under roofs



- South exposition can be calculated
  (no measurement data available)
  - Temperatures on South roof not much higher than exposition East

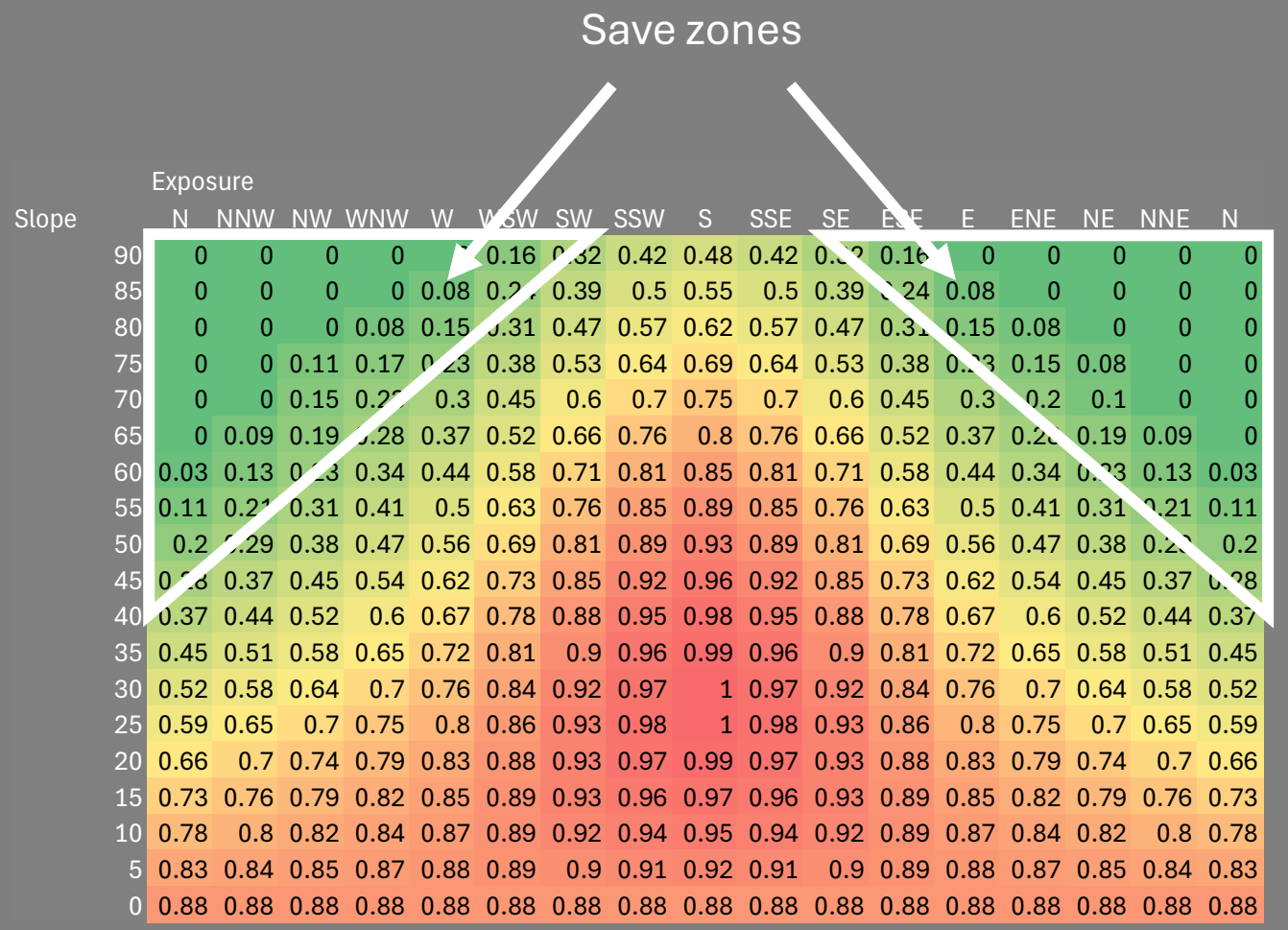
Data: Henk Schröder (2024)

Date: 25 June 2023

What did the SMP NCG do with the results?

- Arcadis gave advice to further restrict the use roof tiles for swifts
  - Preferably only on North facing roofs

- A better advice would probably have been:
  - Use tiles for swifts only in the green triangles of the Exposure-Slope-Index diagram (values <= 0. 28)



What can we learn from this?

- Maximum temperature under roofs
  - generally 20-30 °C higher than maximum air temperature in the shade outside

- In NW-Europe frequently 30 °C in summer → 50-60 °C under roofs
  - Too hot for swifts (warmer than body temperature)

- Not taken into account: ventilation of construction
  - Today's roofs ≠ Roofs of 50 years back

What can we learn from this?

- In Southern Europe most likely (until proven otherwise)
  - temperatures under roofs are also 20-30 °C higher than air temperature in the shade outside during warm episodes
  - With air temperature of 40 °C → temperatures rise to 60-70 °C under roofs → A lot of young swifts in rehabilitation
  - Although some nesting places may not be situated directly under the roof, but in attics: hot as well

Gierzwaluwen nader bekeken: tien jaar waarnemingen met camera's bij nesten

Jonge Gierzwaluwen op de uitkijk vlak voor het uitvliegen, Julianadorp, 13 juli 2009. *Young Swifts on the lookout just before fledging.* (foto Henk Post)

LIMOSA 88 (2015): 57-73

lboer

Article on breeding biology of swifts studied by camera's

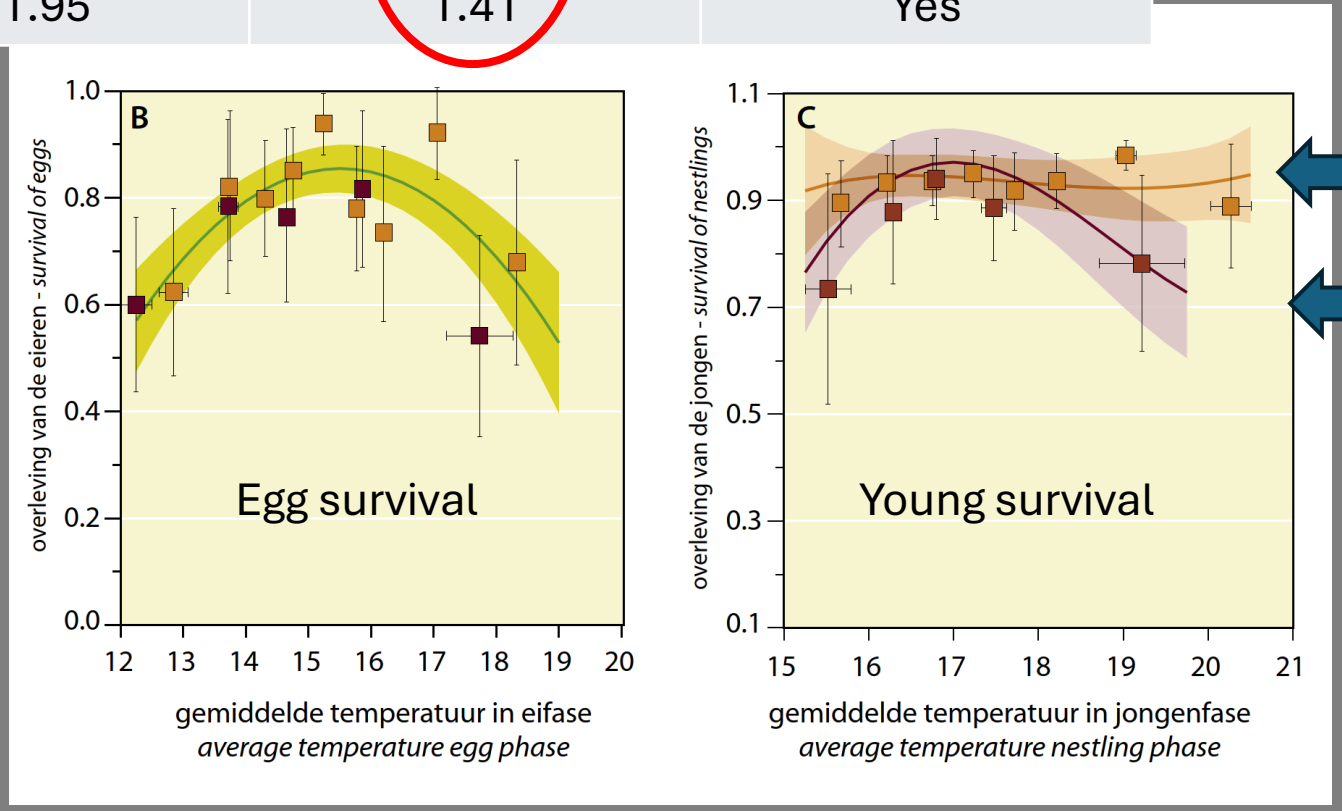
- 40 sites in NL
- 10 year period
- 659 clutches followed

Artificial versus ‘natural’ nesting sites

	Artificial	Natural	Difference significant?
# Clutches	254	100	
# Eggs	2.53	2.31	Yes
# Young	2.10	1.70	Yes
# Young fledged	1.95	1.41	Yes

Lower!

Moreover, at higher temperatures, more young die in ‘natural’ nest sites



Nestboxes

‘Natural’

What can we learn from this?

- We should aim at a climate-proof population of swifts → make climate-proof nesting sites!

Thank you!

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