

# Modelling mould growth in domestic environments using relative humidity and temperature

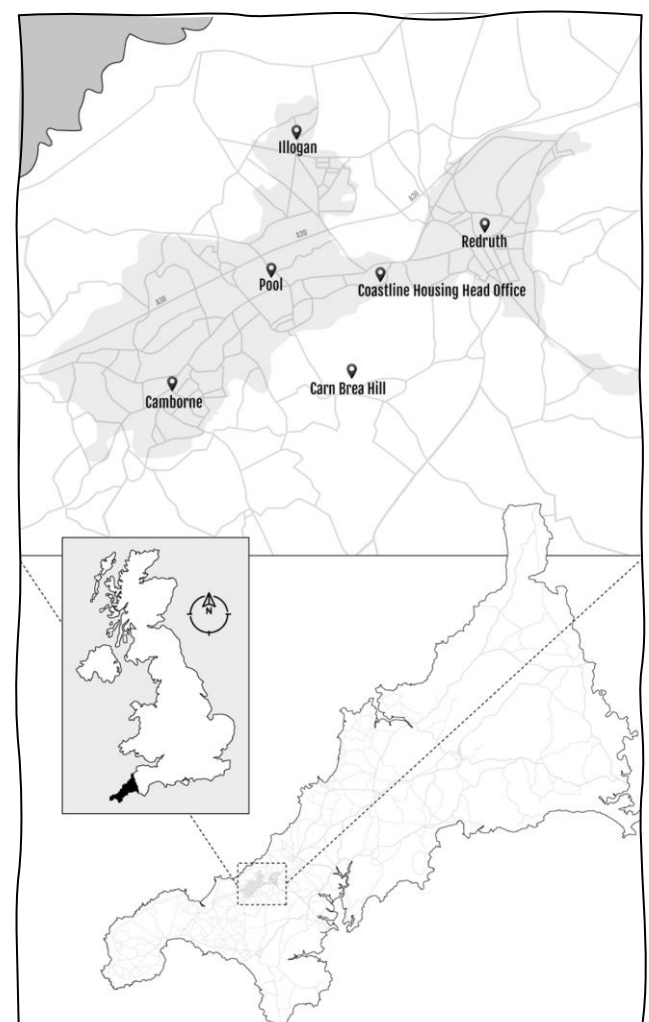
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European Centre for Environment and Human Health  
Environment and Sustainability Institute

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## Smartline

- 300+ participants from social housing
- Camborne, Pool, Illogan and Redruth, in Cornwall, UK
- Sensors and surveys



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## Survey data

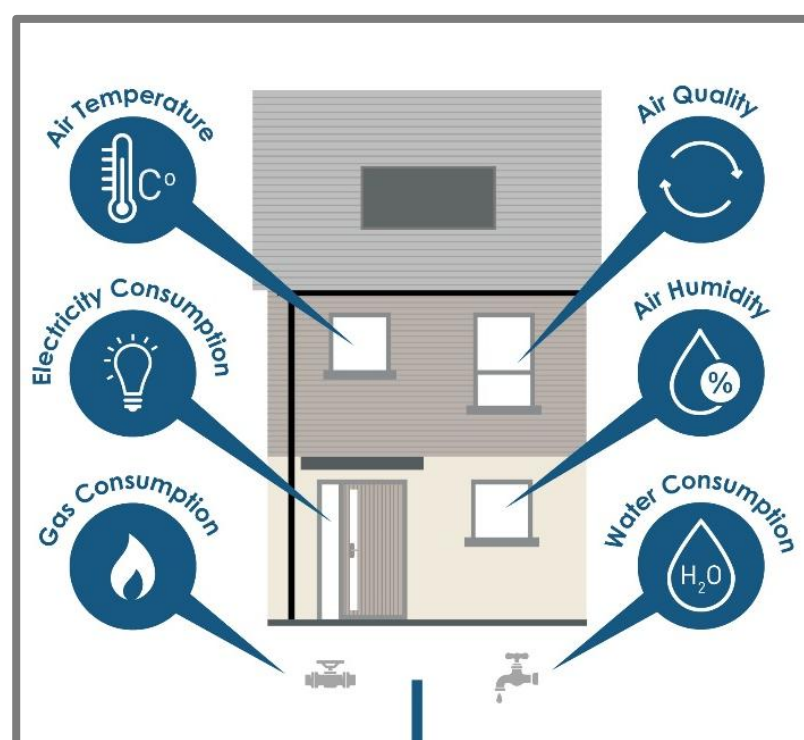
- 95% white
- Two thirds female
- Average age 56
- Under-served areas
- One fifth no Internet
- 19.5 hours per day at home



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## Sensor data

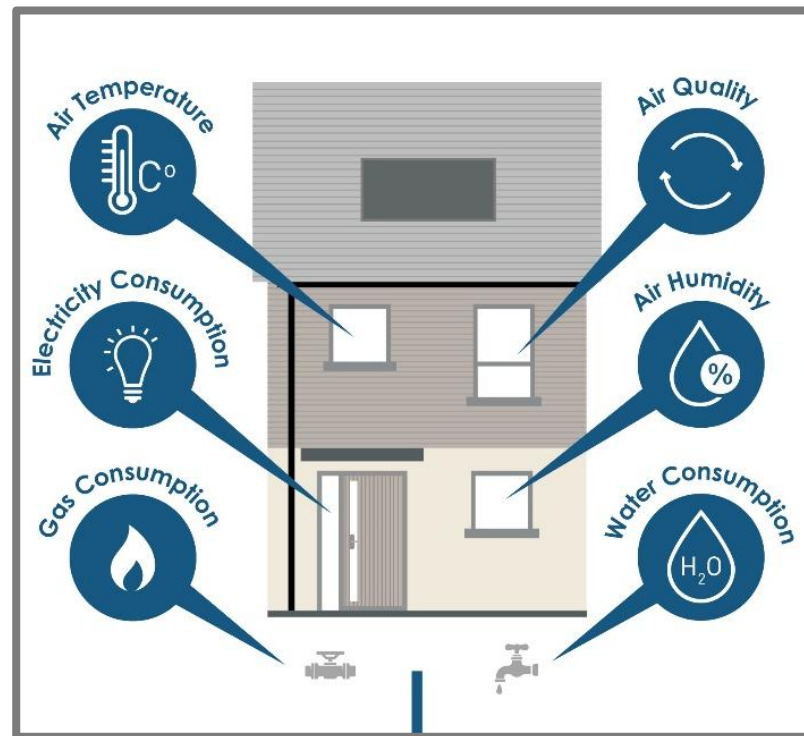
- Temperature
- Relative humidity
- Air quality
- External
- Utilities: Electricity, gas, water



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## Sensor data

- Temperature
- Relative humidity
- Air quality: VOCs, PM2.5
- External
- Utilities: Electricity, gas, water



Woods, Menner, et al. (2023). Smartline Environmental Sensor Data and Utility Usage, 2017–2023. <https://reshare.ukdataservice.ac.uk/856596/>

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## Survey: Mould

Does your home have visible mould patches?

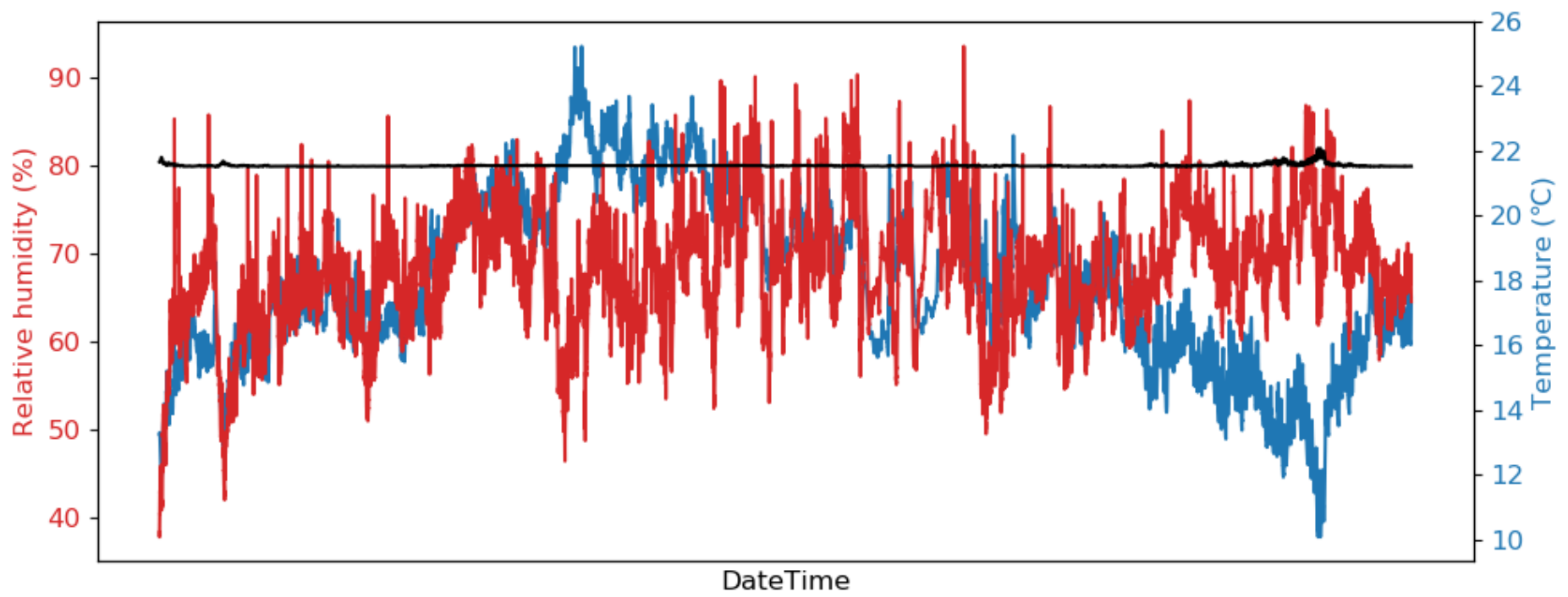
- 44% responded “Yes”

Has your home suffered from a mouldy/musty odour in last 12 months?

- 18% responded “Yes”

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## Relative humidity and temperature



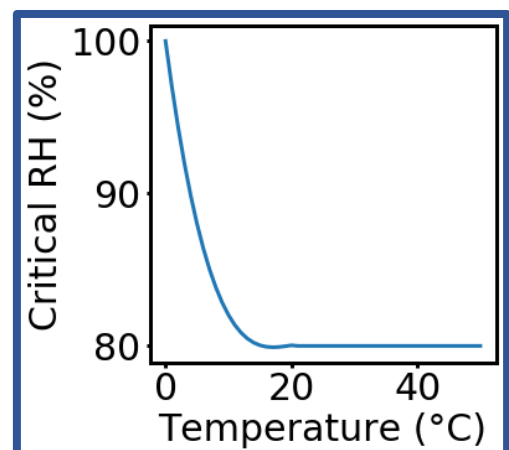
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## VTT model (Viitanen, 1997; Hukka & Viitanen, 1999)

$$RH_{crit} = \begin{cases} -0.0026T^3 + 0.160T^2 - 3.13T + 100.0 & \text{when } T \leq 20 \\ 80\% & \text{when } T > 20 \end{cases}$$

Current RH above critical level:

$$\frac{dM}{dt} = \frac{1}{7 \times e^{(-0.68 \ln(T) - 13.9 \ln(RH) + 0.14W - 0.33SQ + 66.02)}}$$

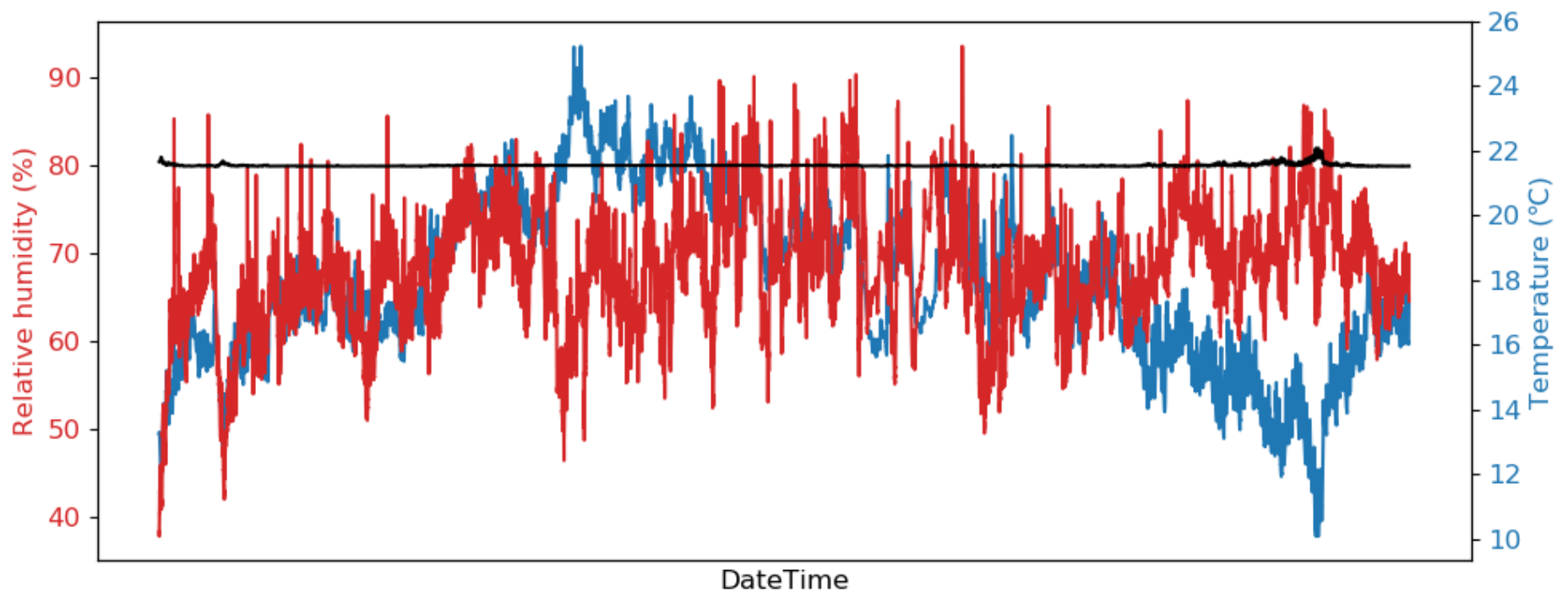


Current RH below critical level:

$$\frac{dM}{dt} = C_{decline} \begin{cases} -0.032 & \text{when } t - t_1 \leq 6h, \text{ or for nonwood surface} \\ 0 & \text{when } 6h < t - t_1 \leq 24h \\ -0.016 & \text{when } t - t_1 > 24h \end{cases}$$

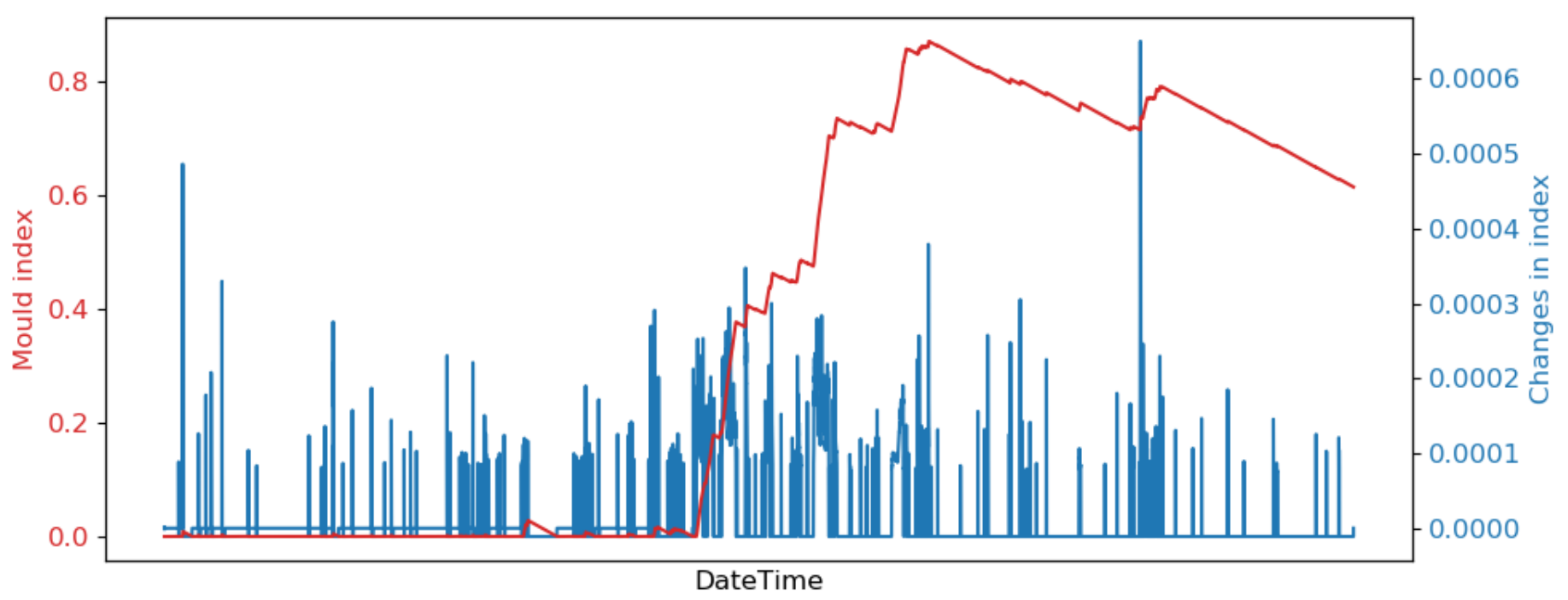
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## Relative humidity and temperature



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## VTT output



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## VTT model (Viitanen, 1997; Hukka & Viitanen, 1999)

$$RH_{crit} = \begin{cases} 0.0026T^3 + 0.160T^2 - 3.13T + 100.0 & \text{when } T \leq 20 \\ 80\% & \text{when } T > 20 \end{cases}$$

Sensitivity

Time between readings

360 separate models:

- Each combination of model values
- Data from living room or bedroom

Current RH above critical level:

$$\frac{dM}{dt} = \frac{1}{7 \times e^{-0.68 \ln(T) - 13.9 \ln(RH) + 0.14W - 0.335Q - 66.02}}$$

Current RH below critical level:

$$\frac{dM}{dt} = C_{decline} \begin{cases} -0.032 & \text{when } t - t_1 \leq 6h, \text{ or for nonwood surface} \\ 0 & \text{when } 6h < t - t_1 \leq 24h \\ -0.016 & \text{when } t - t_1 > 24h \end{cases}$$

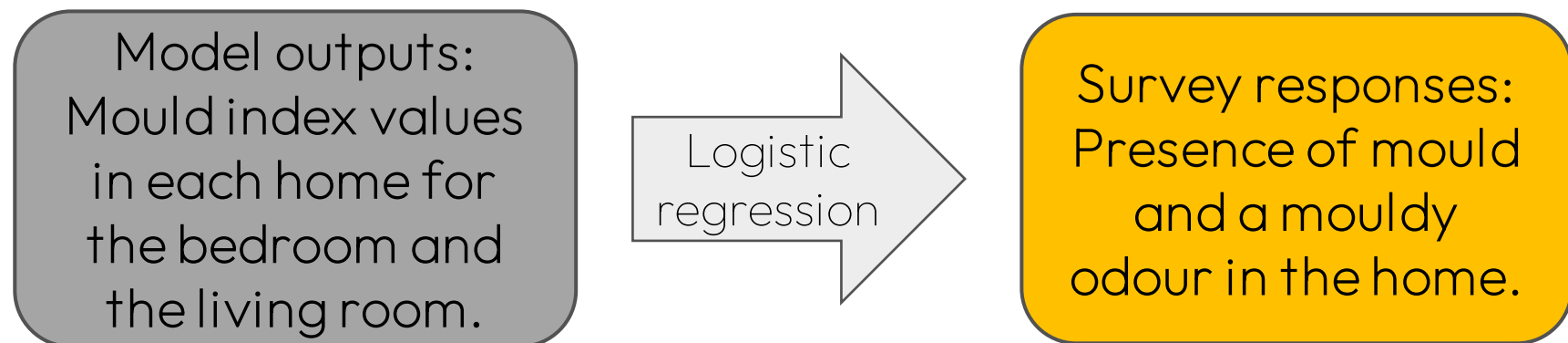
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## Parameter space 2

Parameter	Values
Resampling interval (minutes)	5, 60
Sensitivity	VeryX2
Default $RH_{crit}$ (%)	40, 45, 50, 55, 60, 65, 70, 75, 80
Coefficient for T, pT	0.34
Coefficient for RH, pRH	6.95
Constant, pC	33.01
Method of decline	Wood (W), Non-wood (NW)
$C_{decline}$	0.1

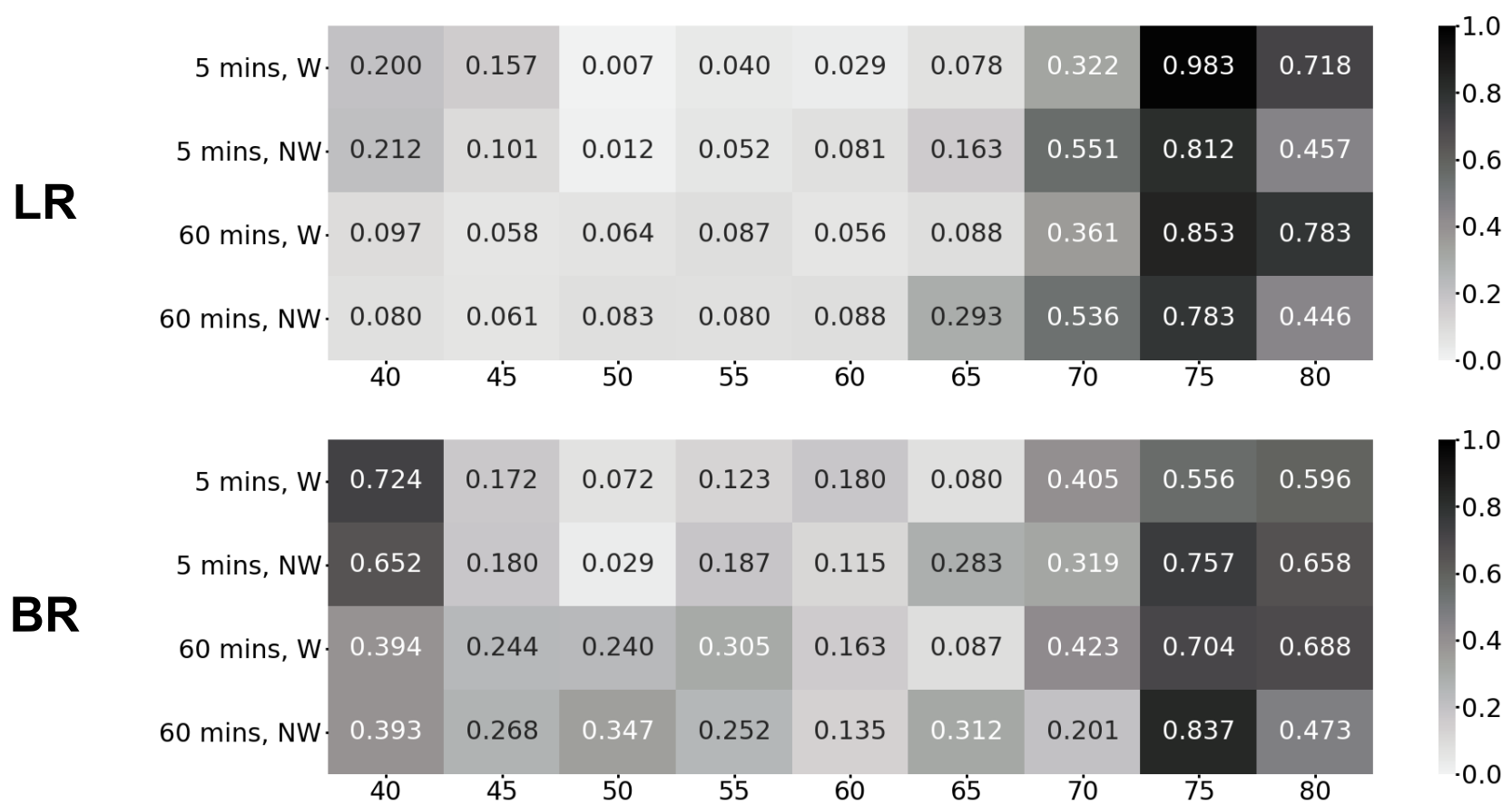
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## Evaluating the model outputs



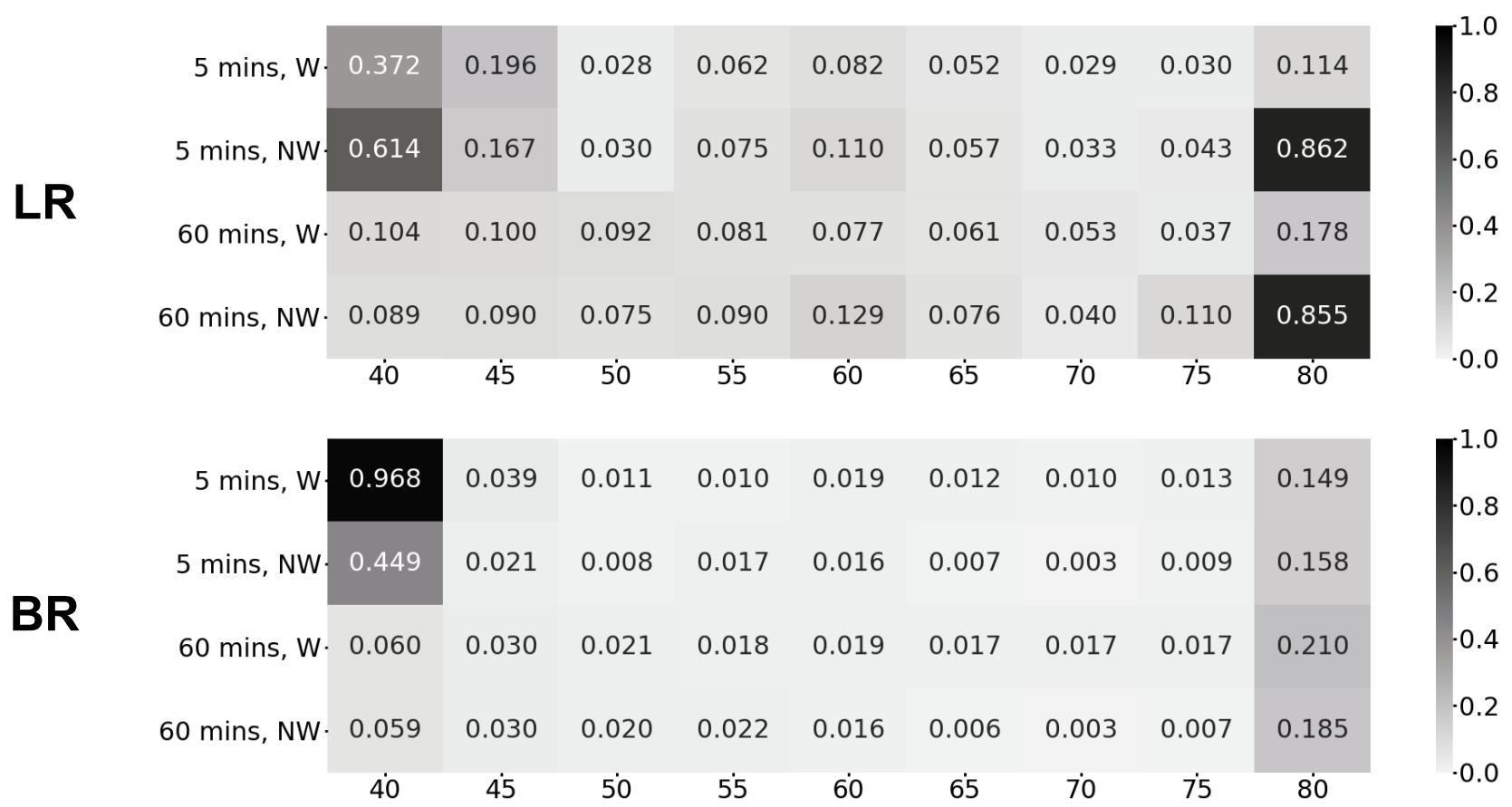
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## Survey = Mould



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## Survey = Odour



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Survey response	Sensor data room	Default RH <sub>crit</sub> (%)	p	TPR	TNR	Precision	Balanced accuracy	F1	Chance-level F1 (SD)	SDs above chance F1
Mould	Living room	50	0.012	0.833	0.431	0.594	<u>0.632</u>	<u>0.694</u>	0.671 (0.006)	3.896
Odour	Bedroom	50	0.008	0.769	0.652	0.333	<u>0.712</u>	<u>0.465</u>	0.335 (0.023)	5.688

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## Summary

- Model improved when made more sensitive
  - Critical RH <80%
  - Air versus surfaces
- Mould versus mouldy odour
- Adding value to sensor data
- Future smart control
  - Dynamic model



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