Modelling mould growth using relative humidity and temperature time-series data

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INTRODUCTION

- Mould has an adverse affect on health, e.g., asthma and other respiratory diseases (Sharpe et al., 2015).
- The VTT model predicts mould growth from relative humidity (RH) and temperature (Hukka & Viitanen, 1999). It was developed using surface readings on wood in a controlled laboratory setting.

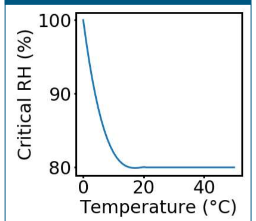
VTT MODEL

The VTT model establishes a mould index M as a function of RH and temperature.

The model determines the rate of change $\frac{dM}{dt}$ according to a critical RH value.

Critical RH, above which mould starts to grow is given by:

Figure 1: Critical RH function of temperature.



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

If current RH ≥ RH_{crit} the mould index increases:

T: Temperature | RH: Relative humidity | Constant

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

Coefficients for T and RH | W: Wood type | SQ: Surface quality

$\frac{dM}{dt}$ is moderated by a sensitivity level (resistant to very), and by the current mould index (maximum of 6).

If current RH < RH_{crit} the mould index can decline

- Dependent on decline type. Default is -0.032, but for wood it depends on the time for which RH < RH_{crit}

$$\frac{dM}{dt} = \begin{cases} -0.032 & when\ t - t_1 \leq 6h \\ 0 & when\ 6h \leq t - t_1 \leq 24h \\ -0.016 & when\ t - t_1 > 24h \end{cases}$$

- Multiplied by a decline rate (0.1 to 1).

AIM

We test the generalisability of the laboratory-based VTT model to less controlled domestic environments on an unprecedented scale by comparing model predictions for 274 homes with occupants' responses about mould.

DATA and ANALYSIS

Data from 274 homes across Cornwall (Coastline Housing Ltd.).

- Time-series air readings of RH and temperature
  - every 3-5 minutes;
  - November 2018 to October 2019;
  - bedroom (BR) and living room (LR).
- Occupants' self-reported responses regarding the presence of mould and a mouldy odour.

Table 1: Parameter spaces for the VTT model

Parameter space	Resampling interval (minutes)	Critical RH Default (%)	Sensitivity	Type of decline	Decline rate	Coefficient for T	Coefficient for RH	Constant
1	5 60	**40** **60** **80**	very very x2	wood other	0.1 1	**0.34** 0.68 1.02	**6.95** 13.9 20.85	**33.01** 66.02 99.03
2	As P1	40 to 80 in steps of 5	very x2	As P1	0.1	0.34	6.95	33.01

Model outputs: Predicted mould index values in each home for each room. → Logistic regression → **Survey responses:** Presence of mould and a mouldy odour in the home.

RESULTS (Parameter Space 2)

Figure 2: Receiver operating characteristic curve, from accuracy and error rates in predicting the presence of a mouldy odour from the mould index calculated from the bedroom RH and temperature.

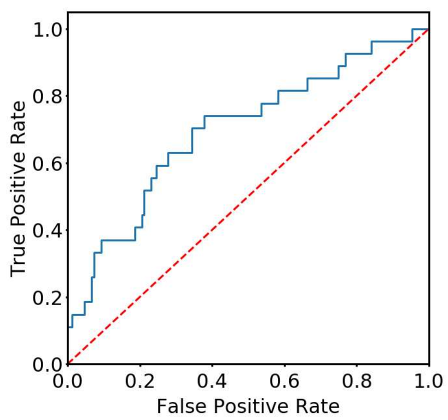
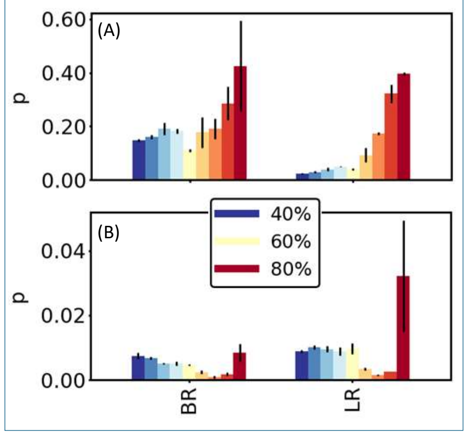


Figure 3: Relationship strengths (smaller is stronger) between model and survey response about mould (A) and odour (B), for each RH_{crit} default and each room.



CONCLUSION and DISCUSSION

The domestic air measurements represent complex interaction between built environment and human behaviours.

The model can predict mould growth when the RH_{crit} default value is reduced from 80%.

Real-time predictions could inform:

1. Early targeted interventions to improve public health and living environments.
2. Smart control to provide the minimum targeted intervention necessary to minimise mould growth and:
   - reduce its impact on health;
   - avoid unintended consequences in homes with reduced ventilation (e.g. energy efficient homes);
   - maintain human comfort;
   - avoid unnecessary power expenditure.
3. Smart monitoring to:
   - alleviate costs of repair associated with mould;
   - be combined with monitoring for other damaging conditions such as cold or damp.

REFERENCES

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